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CONTRACT NAS10-1108

[illegible]TION OF ROCKET ENGINE NOISE DAMAGE TO COMMUNITY DWELLINGS NEAR LAUNCH SITES (FINAL REPORT)

DECEMBER 1964

prepared by

MARTIN COMPANY

DENVER DIVISION

DENVER, COLORADO

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

J. F. KENNEDY SPACE CENTER, FLORIDA

Martin CR-64-65 (Vol II)

Copy No. 35

Contract NAS10-1108

DETERMINATION OF ROCKET ENGINE NOISE DAMAGE TO COMMUNITY DWELLINGS NEAR LAUNCH SITES

(FINAL)

October 1964

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Denver, Colorado
Aerospace Division of Martin-Marietta Corporation

FOREWORD

This report is submitted in accordance with Contract NAS-10-1108, Determination of Rocket Engine Noise Damage to Community Dwellings Near Launch Sites. This report is presented in two volumes. Volume I contains a concise discussion of the study, including the test and analytical work. Volume II, appendix material, is a more detailed presentation of data.

APPENDIX A

DATA FROM FLORIDA TESTS

Data from Florida Tests

The following data were acquired during Phase II of the study. A sinusoidal excitation of 135 db rms sound pressure level (re 0.0002 dynes/cm^2) was generally used. At some frequencies, however, an insufficient quantity of air was available to achieve this level. Linearity tests were also conducted at discrete frequencies. This part of the appendix contains: 1) a Table listing the test structures, window description, and window size; drawings of the windows; and data plots. The acceleration and sound pressure excitation level are plotted on the same graph for each window.

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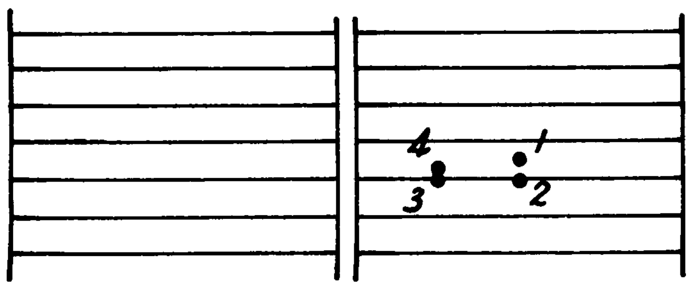
Distribution	

Test Specimens

Item	Location	Use	Construction	Glass Size	Window Type
1.	K8-989	Residence	Blk w/Stucco	4" x 34"	Jalousies
2.	NASA Test Wall	Complex 37	Wood	24" x 24"	Double Hung
3.	NASA Test Wall	Complex 37	Wood	14" x 33"	Awning
4.	NASA Test Wall	Complex 37	Wood	30" x 13"	Double Hung
5.	K8-988	Shopping Center	Block	89" x 61"	Fixed (plate)
6.	K8-988	"	Block	89" x 86"	Fixed (plate)
7.	K8-991	Store	Block	37" x 56"	Fixed
8.	K8-991	Store	Block	12" x 16"	Casement
9.	K8-985	Residence	Block	11" x 34"	Awning
10.	1 mi. N. of Dummit Grove W. side AIA	Residence	Frame and Block	12¼" x 16¼"	Casement
11.	"	Residence	"		Wood Wall
12.	1/4 mi. S. Old Canal W. Side AIA	Residence	Frame	32" x 22"	Fixed
13.	"	Residence	Frame		Wood Wall
14.	1-1/8 mi. N. of Dummit Grove W. side AIA	Residence	Frame	14" x 33"	Casement
15.	1 mi. W. of Wilson N. side 402	Store	Blk w/stucco	83" x 51½"	Fixed (plate)
16.	K8-990	Residence	Blk w/stucco	4" x 34"	Jalousies
17.	NASA Test Wall	Complex 37	Block	48" x 60"	Fixed

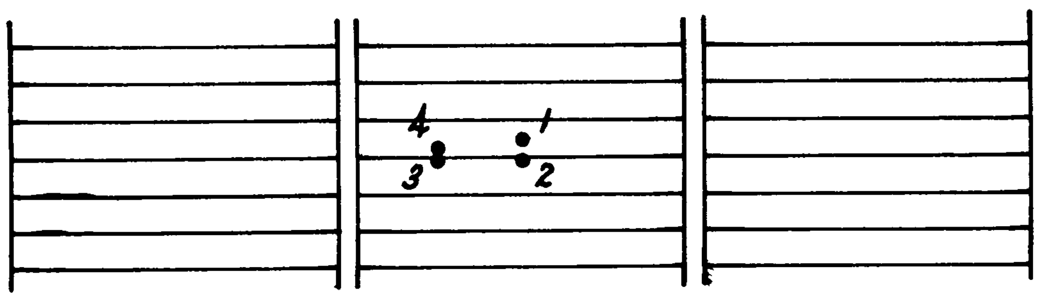
JALOUSY TYPE WINDOWS



Run 1 (KB-989)

Pane Size: 34 x 4 (3/16)

Alum. Sash



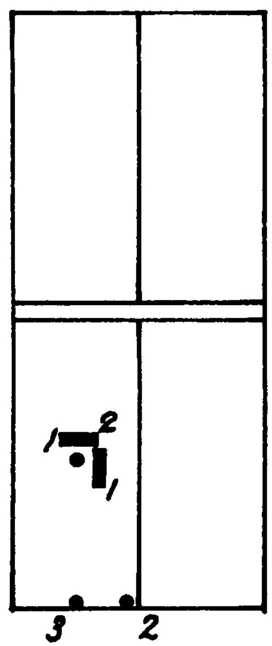
Run 16

Pane Size: 34 x 4 (3/16)

Alum Sash

Figure A-0.1

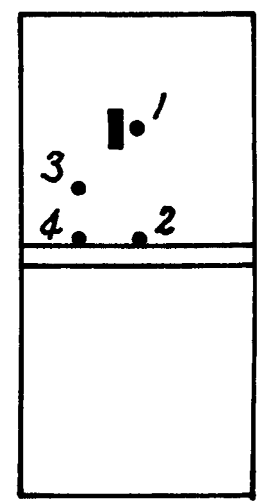
DOUBLE HUNG TYPE WINDOWS



Run 4

Pane Size: 13 x 30 (SS)

Wood Sash



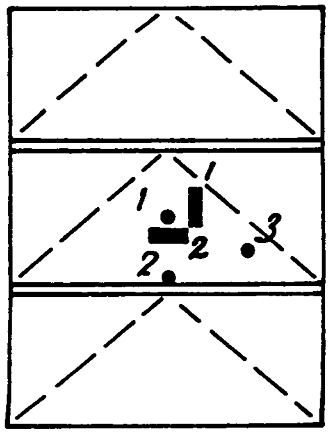
Run 2

Pane Size: 24 x 24 (SS)

Wood Sash

Figure A-0.2

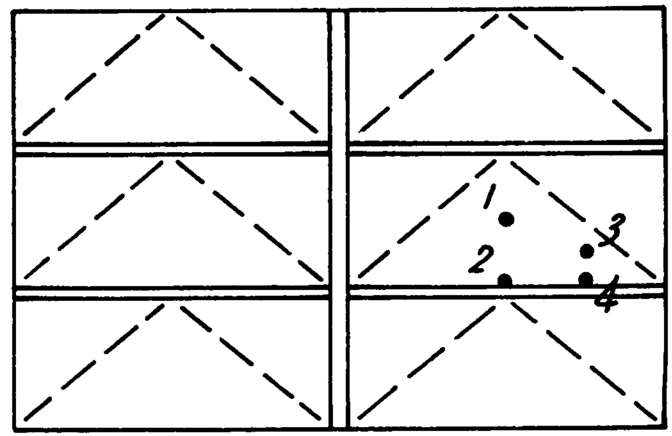
AWNING TYPE WINDOWS

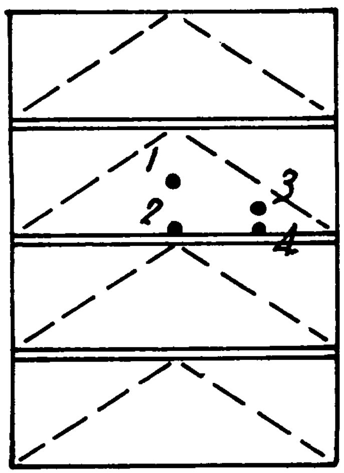


Run 3

Pane Size: 33 x 14 (SS)

Alum. Sash





Run 9 (K8-985)

Pane Size: 34 x 11

Alum. Sash

(Very Loose)

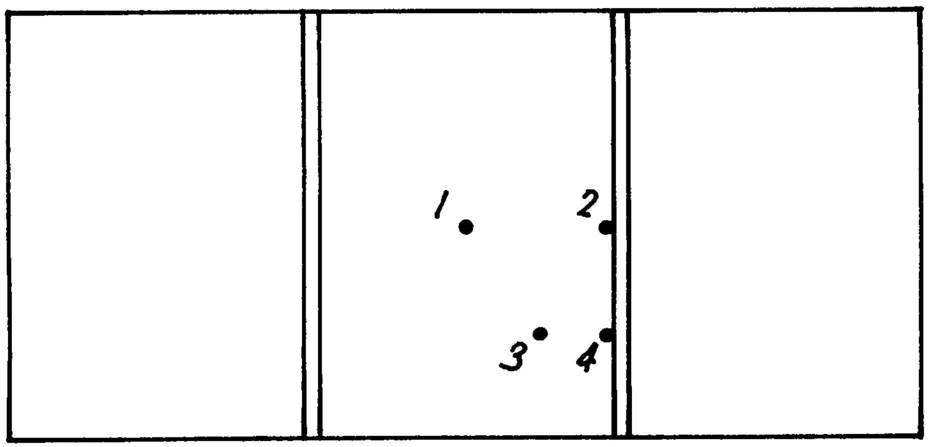
Run 14

Pane Size: 33 x 14

Alum. Sash
Conc. Block Bldg.

Figure A-0.3

FIXED TYPE WINDOWS



Run 6 (K8-988)

Pane Size: 61 x 89 (Plate)

Alum. Frame.

Run 5 (K8-988)

Pane Size: 86 x 89 (Plate)

Alum Frame

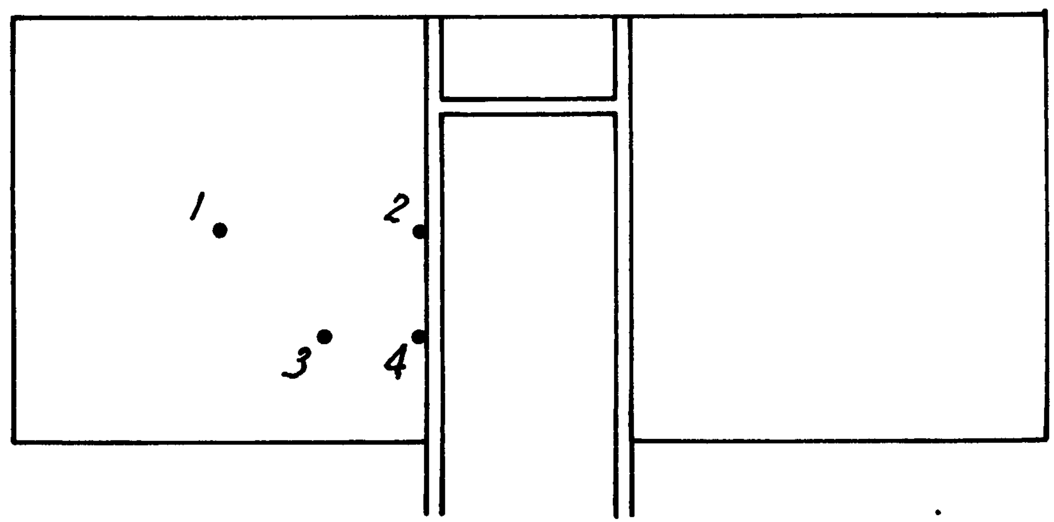
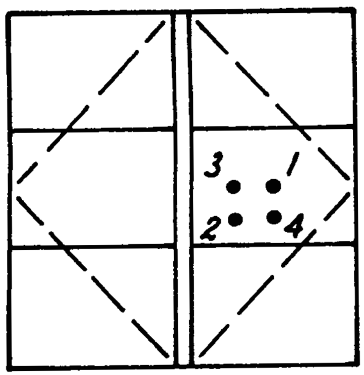


Figure A-0.4

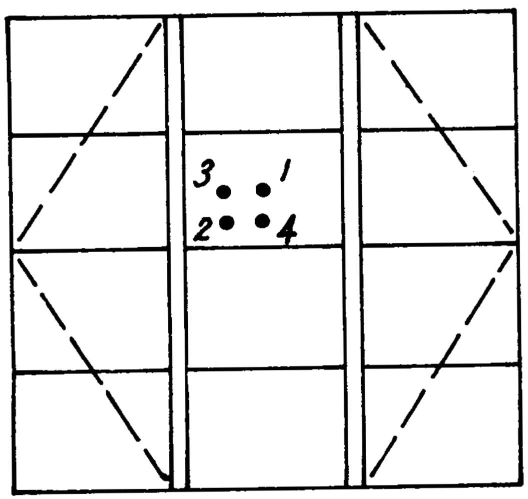
CASEMENT TYPE WINDOWS



Run 8 (K8-991)

Pane Size: 16 x 12 (SS)

Steel Sash



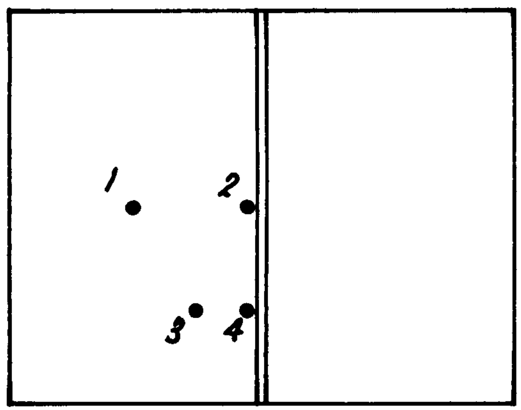
Run 10

Pane Size: 16¼ x 12¼

Steel Sash

Figure A-0.5

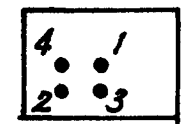
FIXED TYPE WINDOWS



Run 15

Pane Size: 51.5 x 83 (Plate)

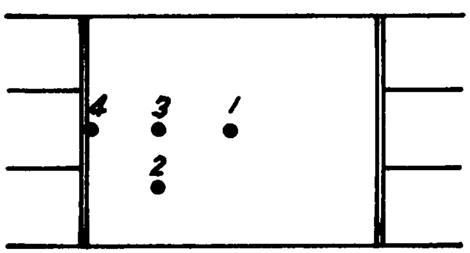
Alum. Frame (Very Thin)



Run 12

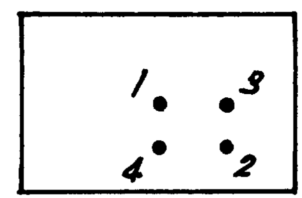
Pane Size: 22 x 32 (SS)

Wood Sash



Run 17

Pane Size: 60 x 48

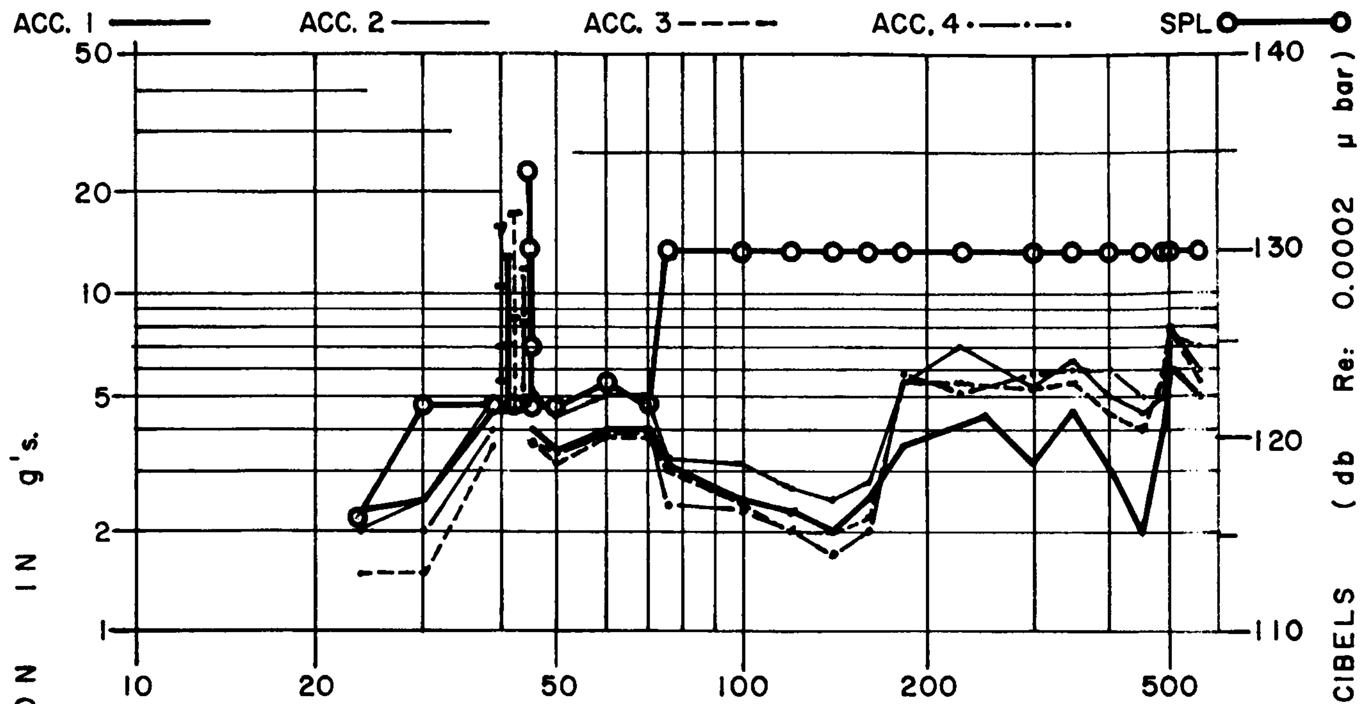


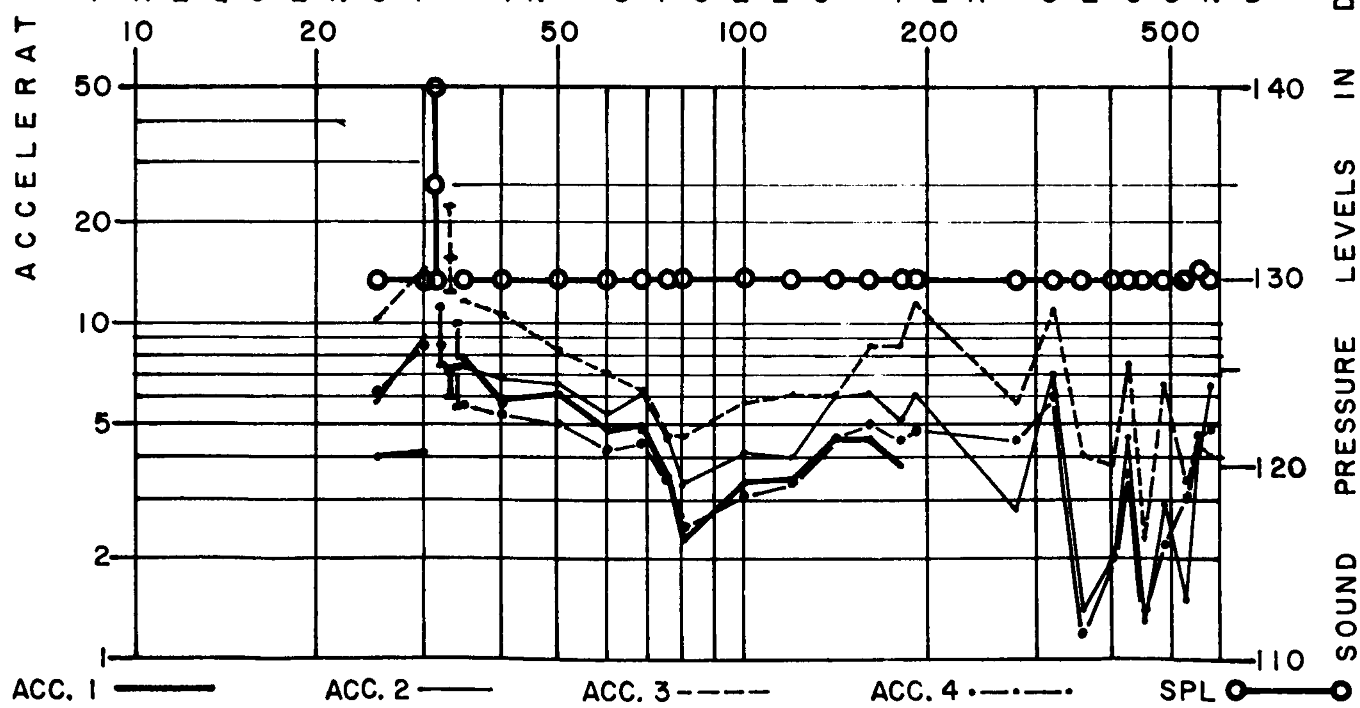
Run 7 (KB·991)

Pane Size: 56 x 37 (SS-?)

Figure A-0.6

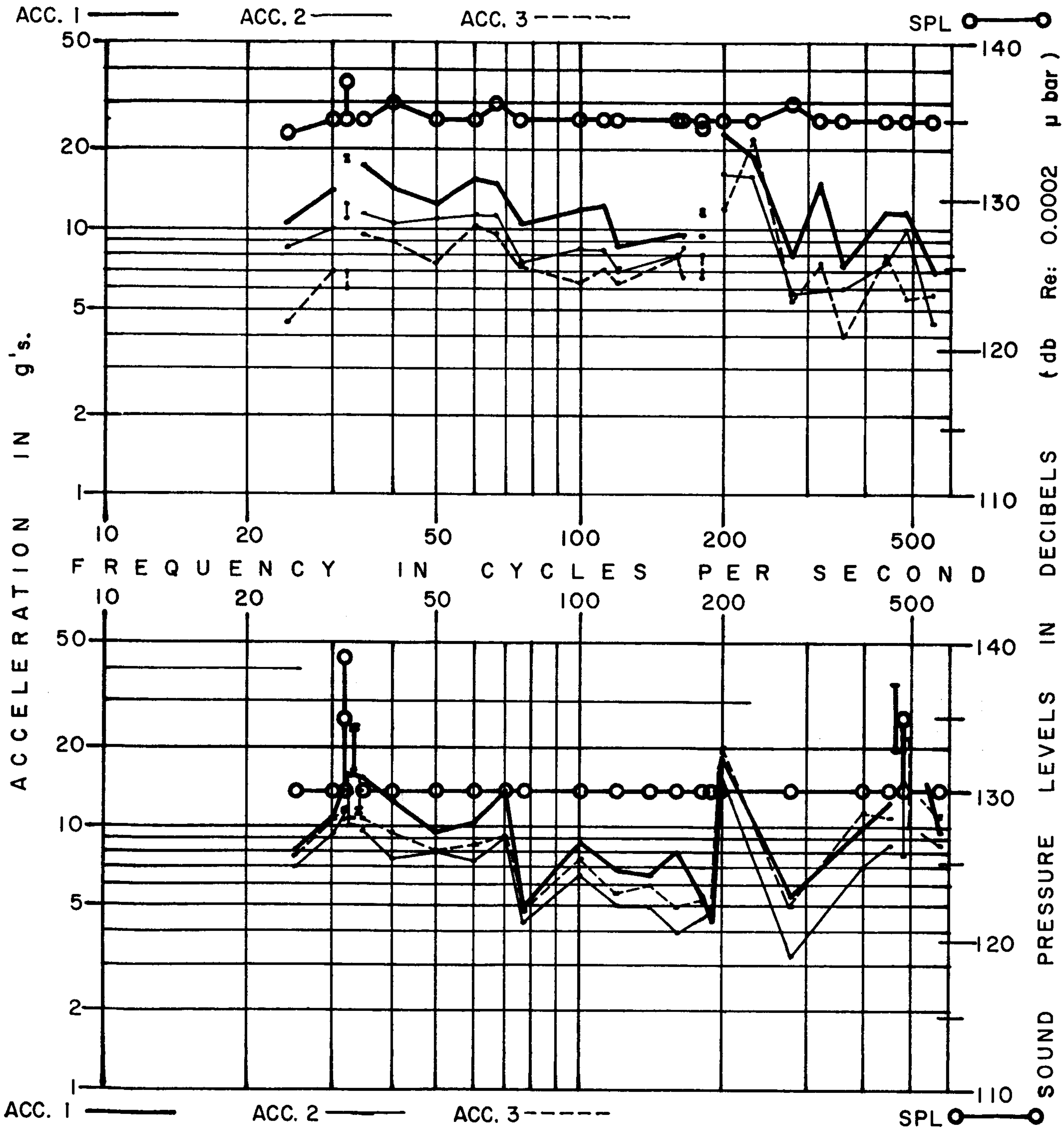
FIGURE A·1
FLORIDA DATA
RUN I





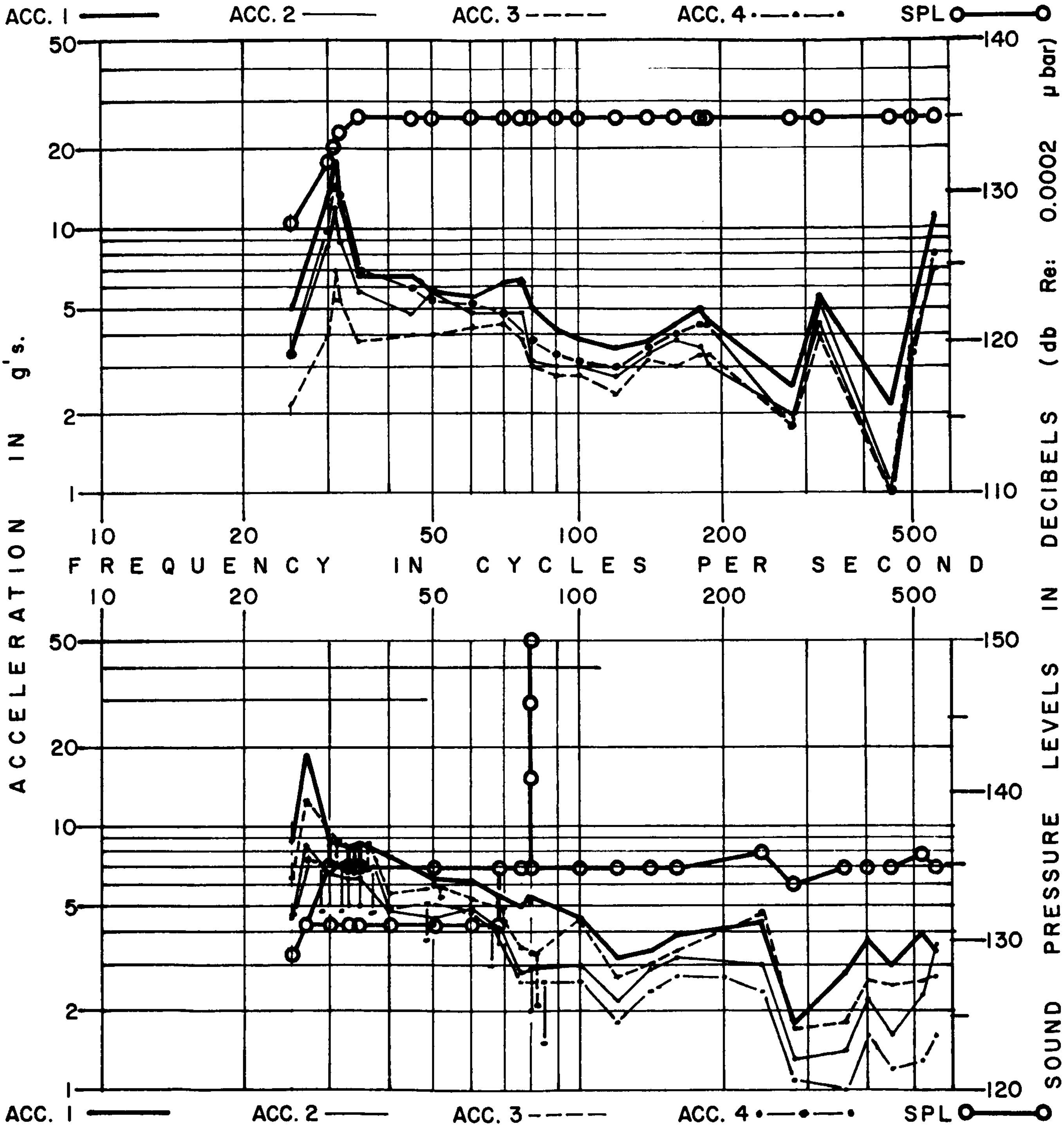
RUN 2
FLORIDA DATA
FIGURE A·2

FIGURE A3
FLORIDA DATA
RUN 3



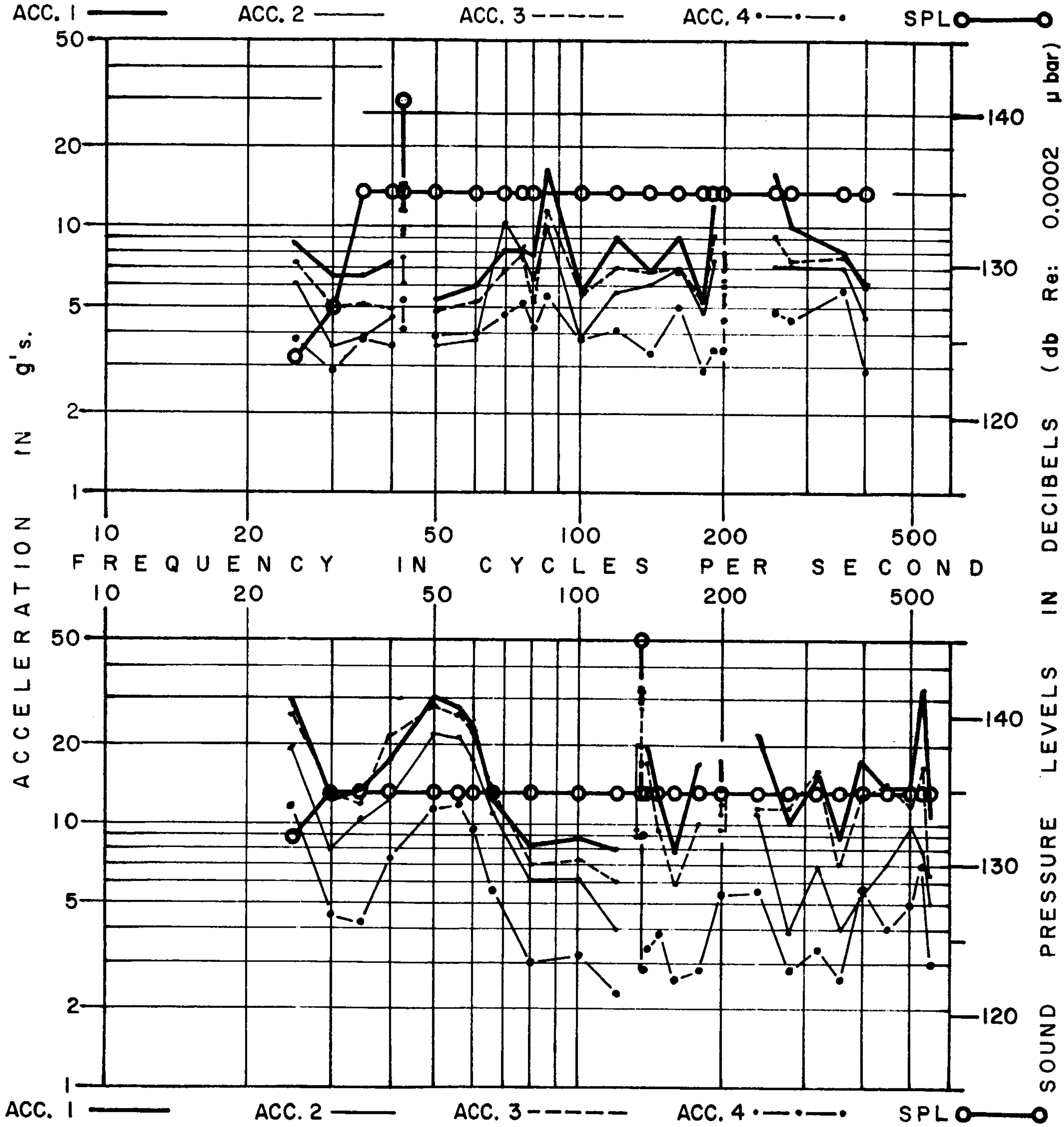
RUN 4
FLORIDA DATA
FIGURE A4

FIGURE A-5
FLORIDA DATA
RUN 5



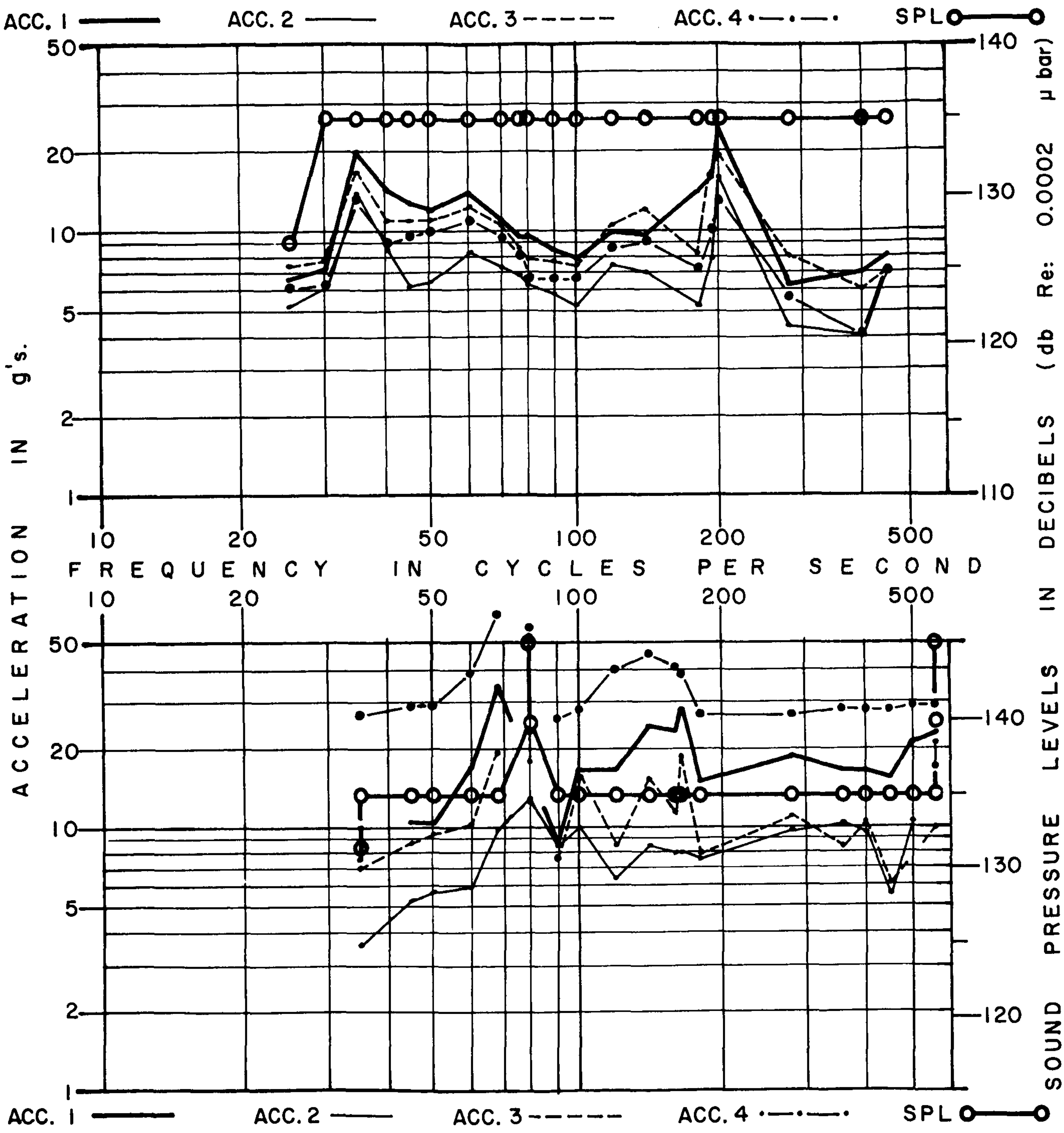
RUN 6
FLORIDA DATA
FIGURE A-6

FIGURE A·7
FLORIDA DATA
RUN 7



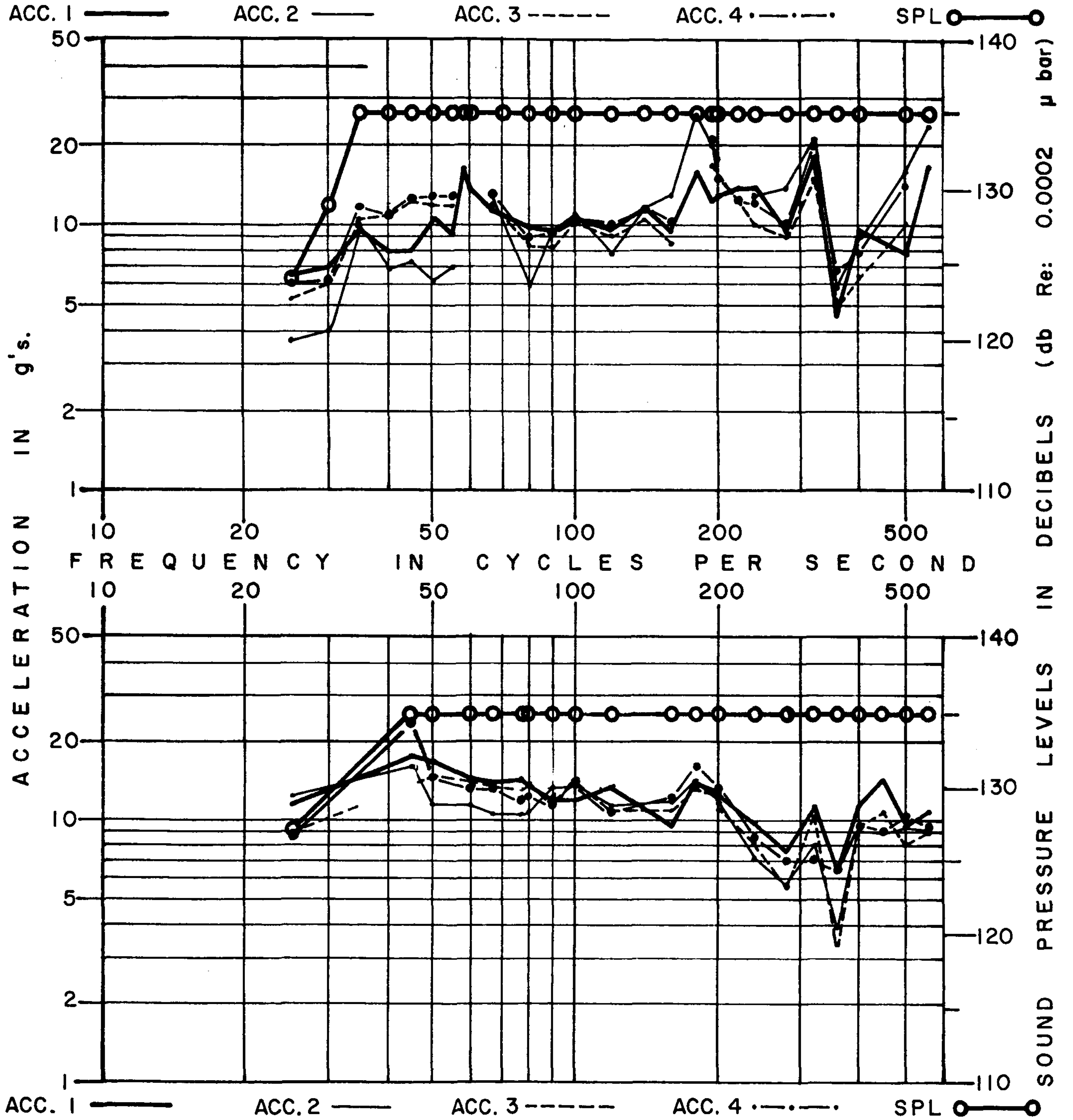
RUN 8
FLORIDA DATA
FIGURE A·8

FIGURE A·9
FLORIDA DATA
RUN 9



RUN 10
FLORIDA DATA
FIGURE A·10

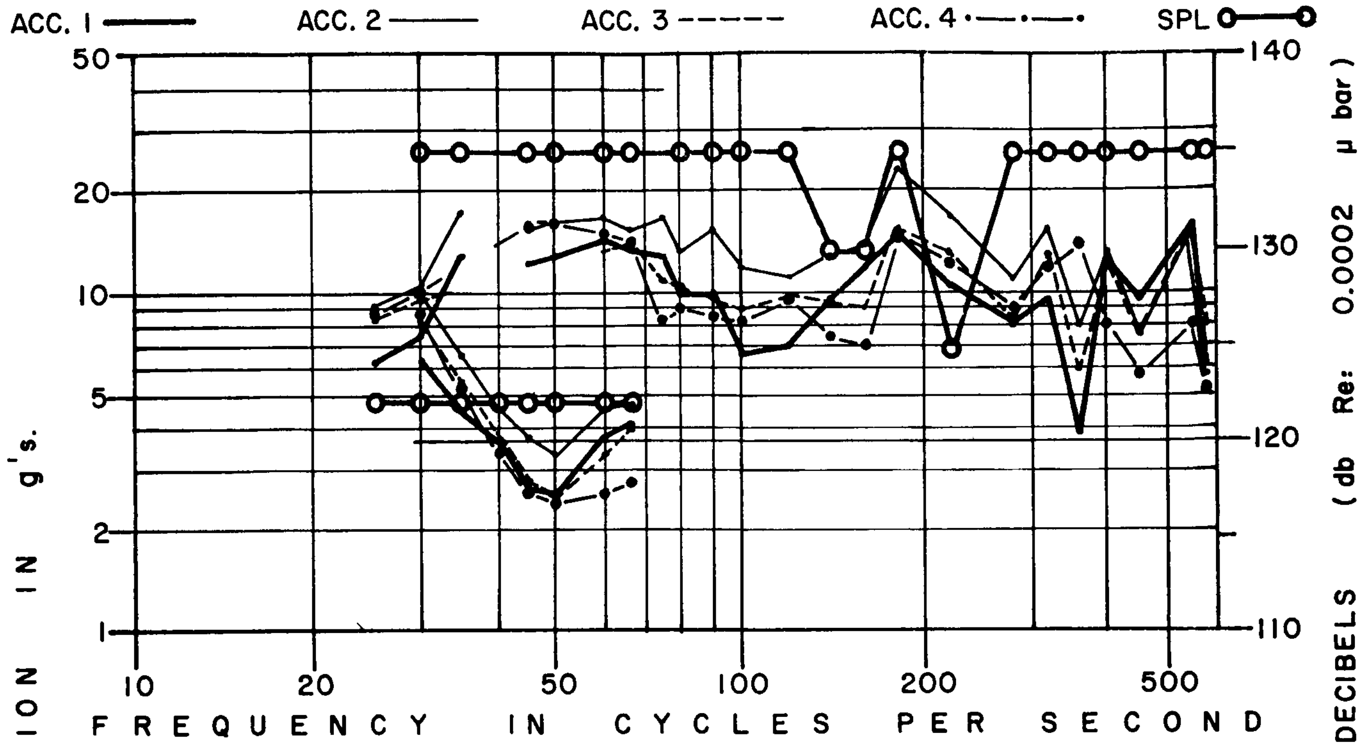
FIGURE A-11
FLORIDA DATA
RUN 11

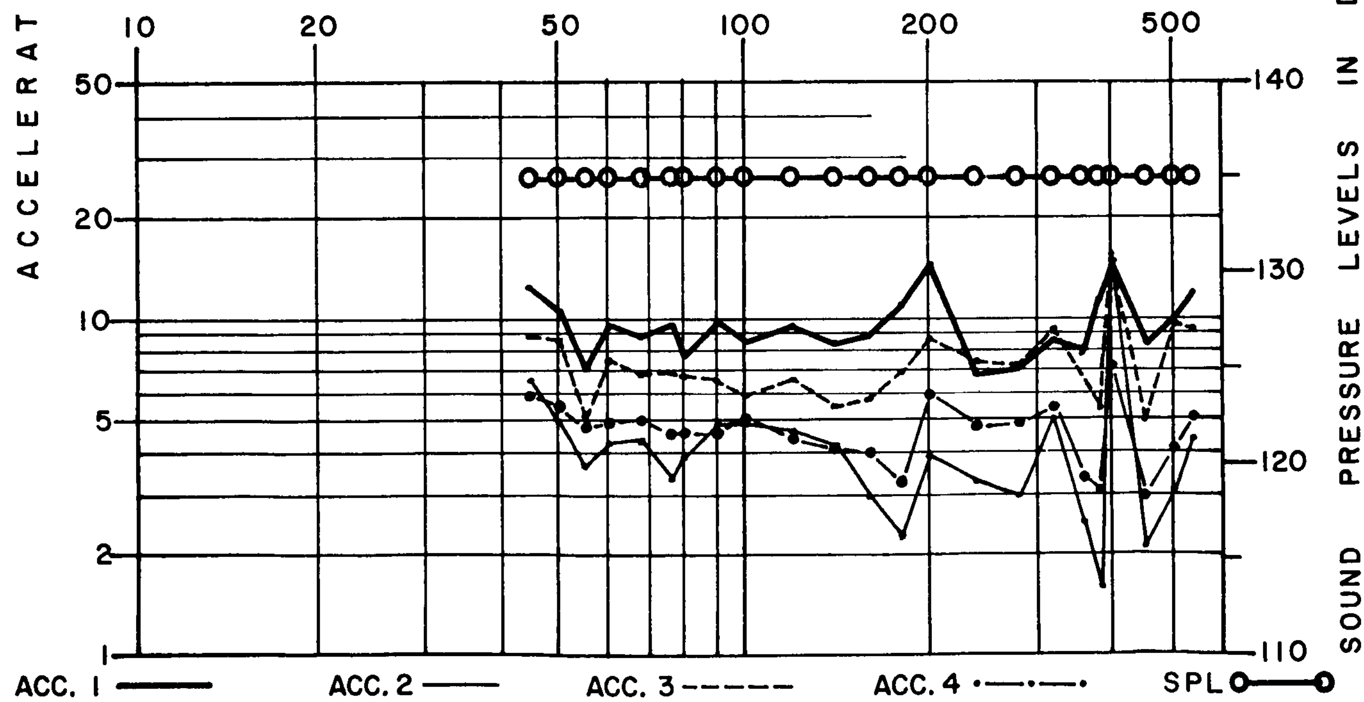


RUN 12
FLORIDA DATA
FIGURE A-12

FIGURE A-13

FLORIDA DATA
RUN 13

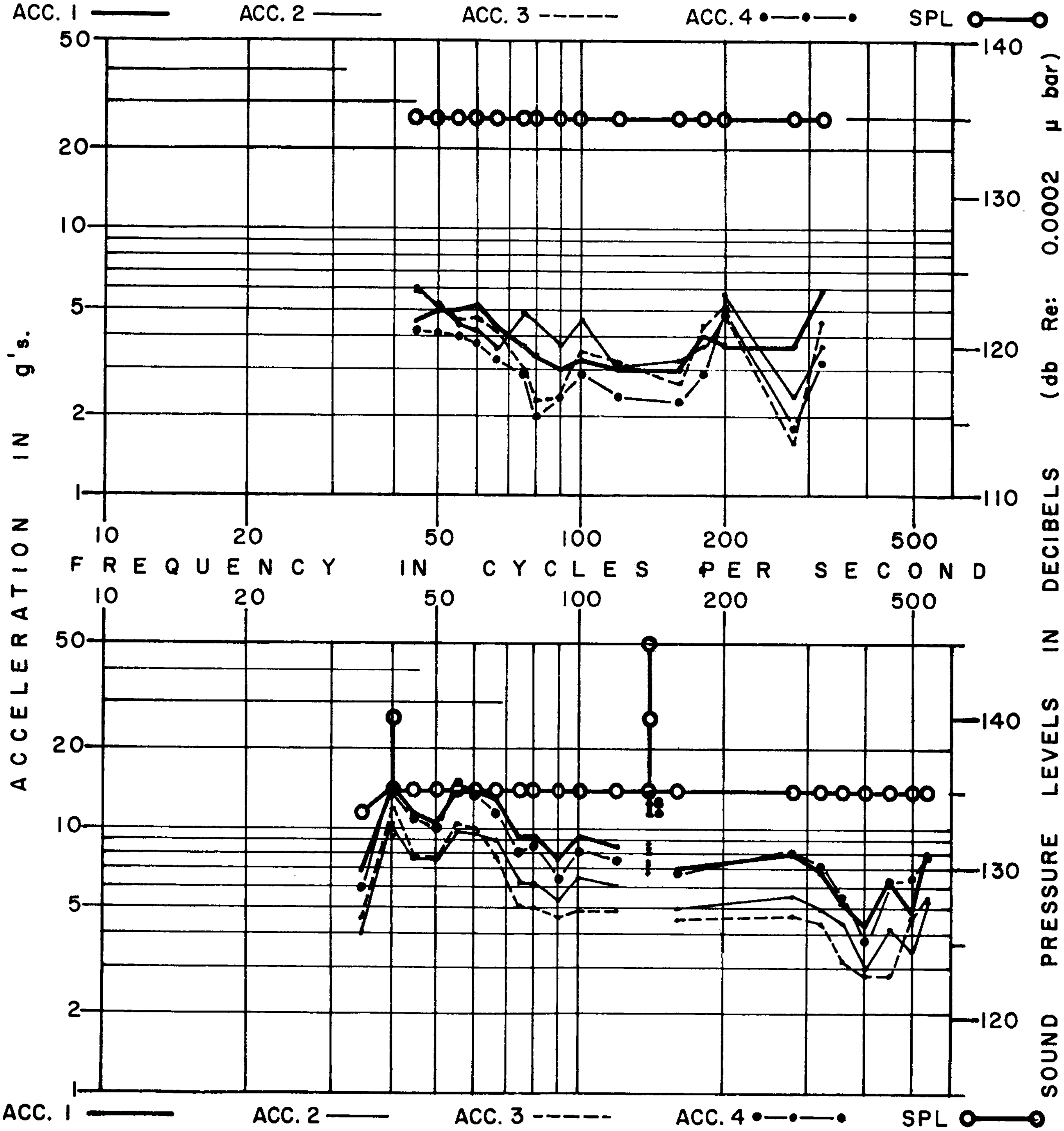




RUN 14
FLORIDA DATA

FIGURE A-14

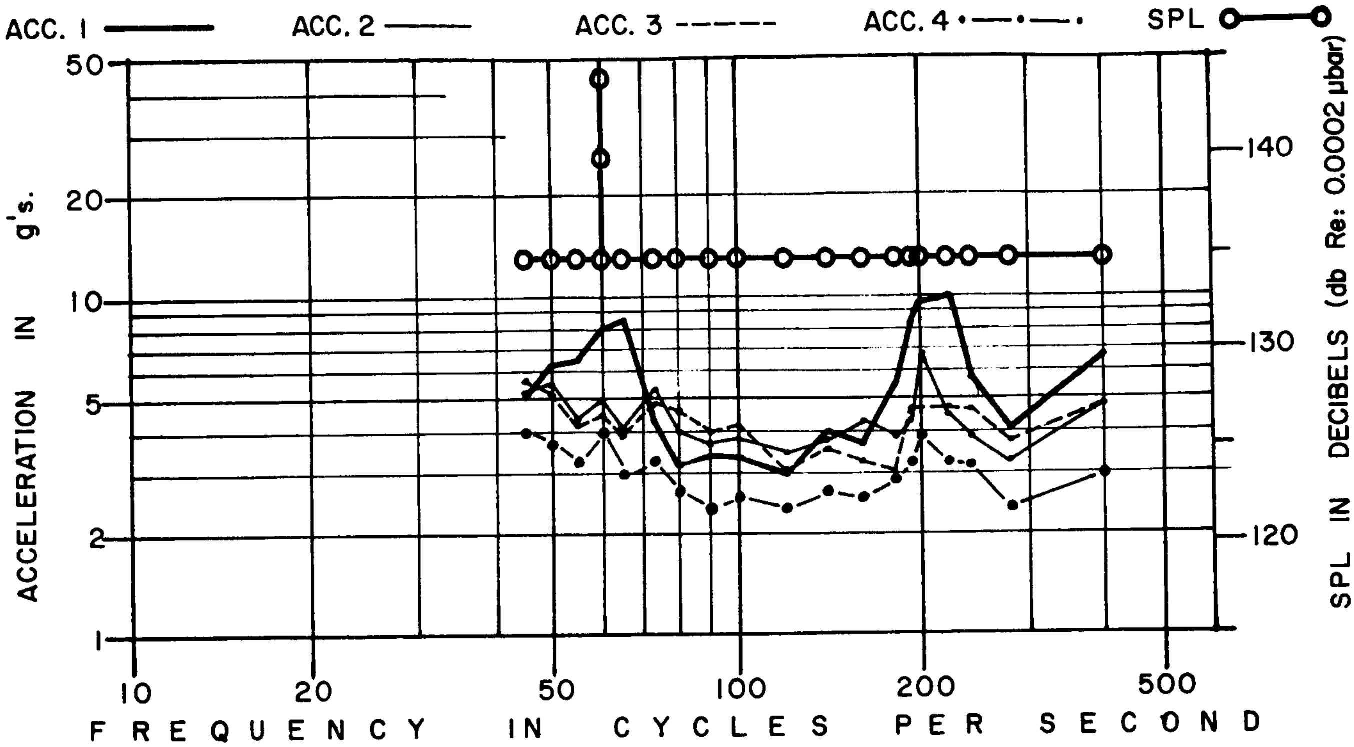
FIGURE A-15
FLORIDA DATA
RUN 15



RUN 16
FLORIDA DATA
FIGURE A-16

FIGURE A-17

FLORIDA DATA
RUN 17



APPENDIX B

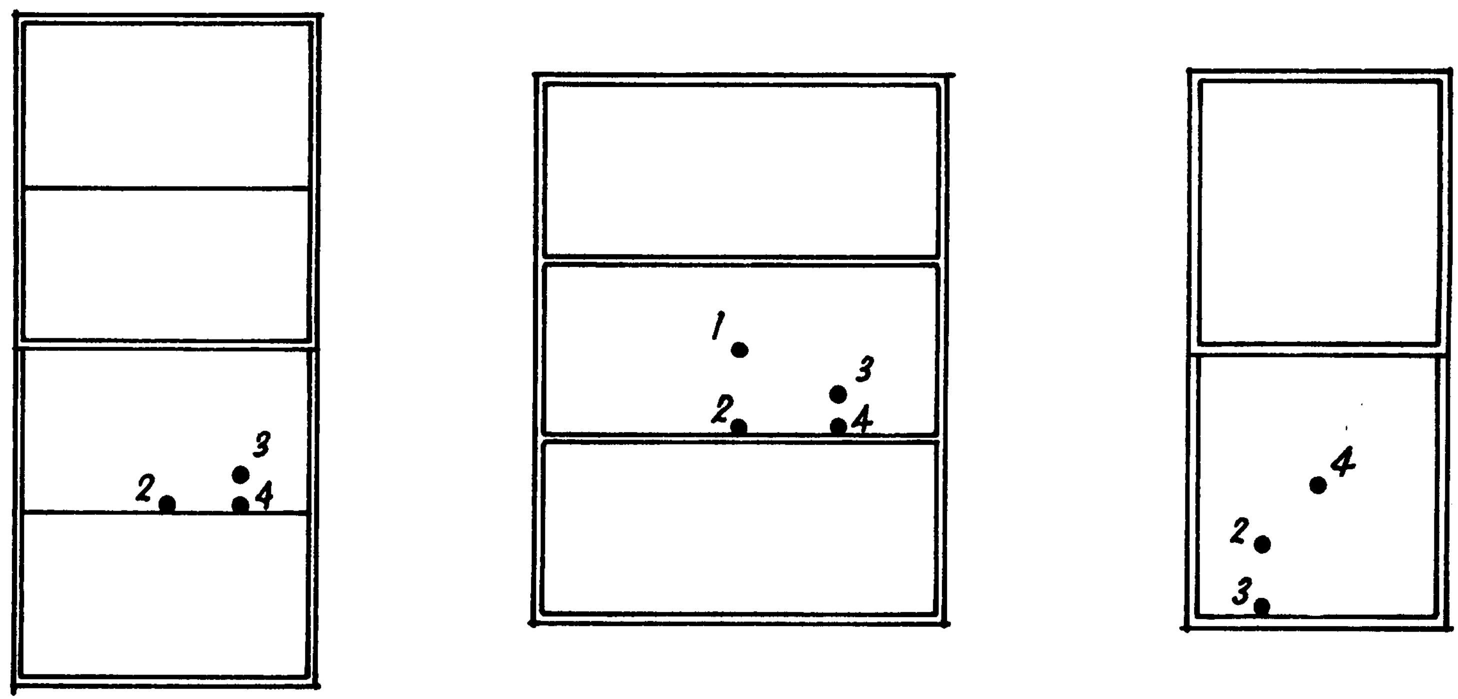
DATA FROM DENVER TESTS

Data from Denver Tests

The following data were acquired during Phase III of the study. Two types of acoustic excitation, random and sinusoidal, were applied to the individual windows of the test panel, which is shown on the following page. The results of the random tests and sinusoidal test are shown in the following graphs.

DENVER DATA

Double Hung | Awning | Double Hung



Run 18
Pane Size: 23 5/8 x 13 5/8
Wood Sash

Run 19
Pane Size: 33 x 14 3/8
Alum. Sash

Run 20
Pane Size: 19 3/4 x 21 3/4
Wood Sash

Figure B-0.1

DENVER DATA

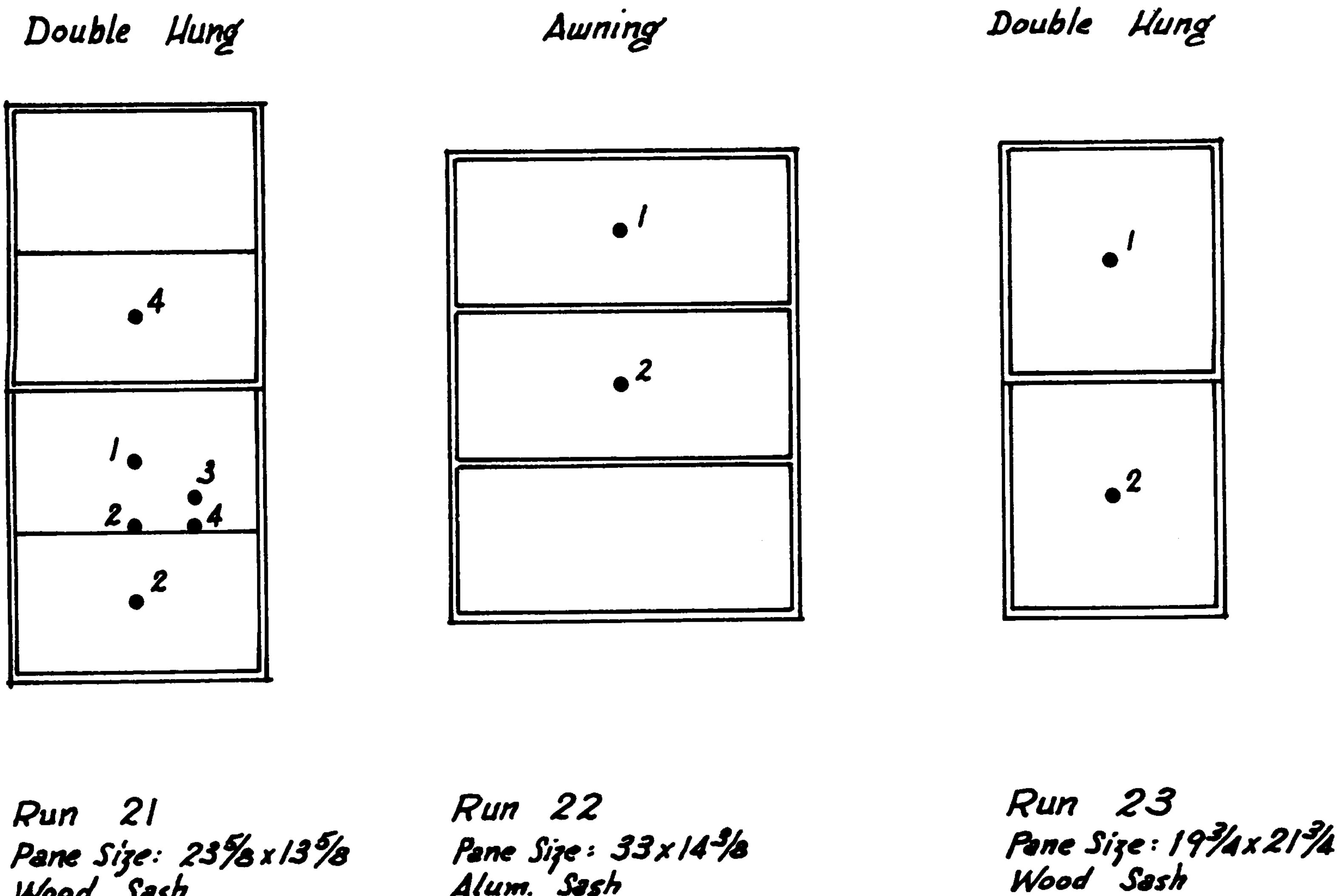
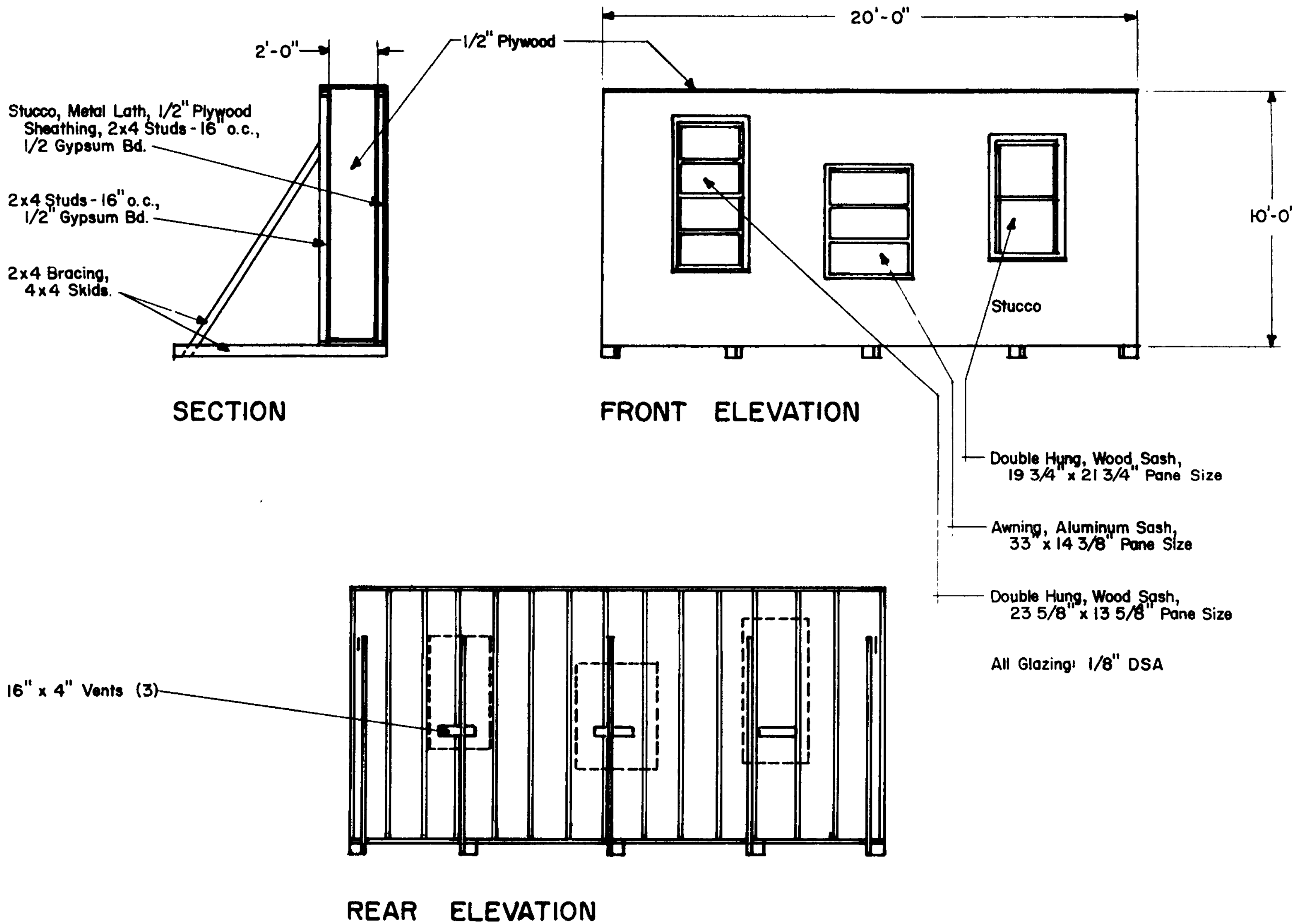
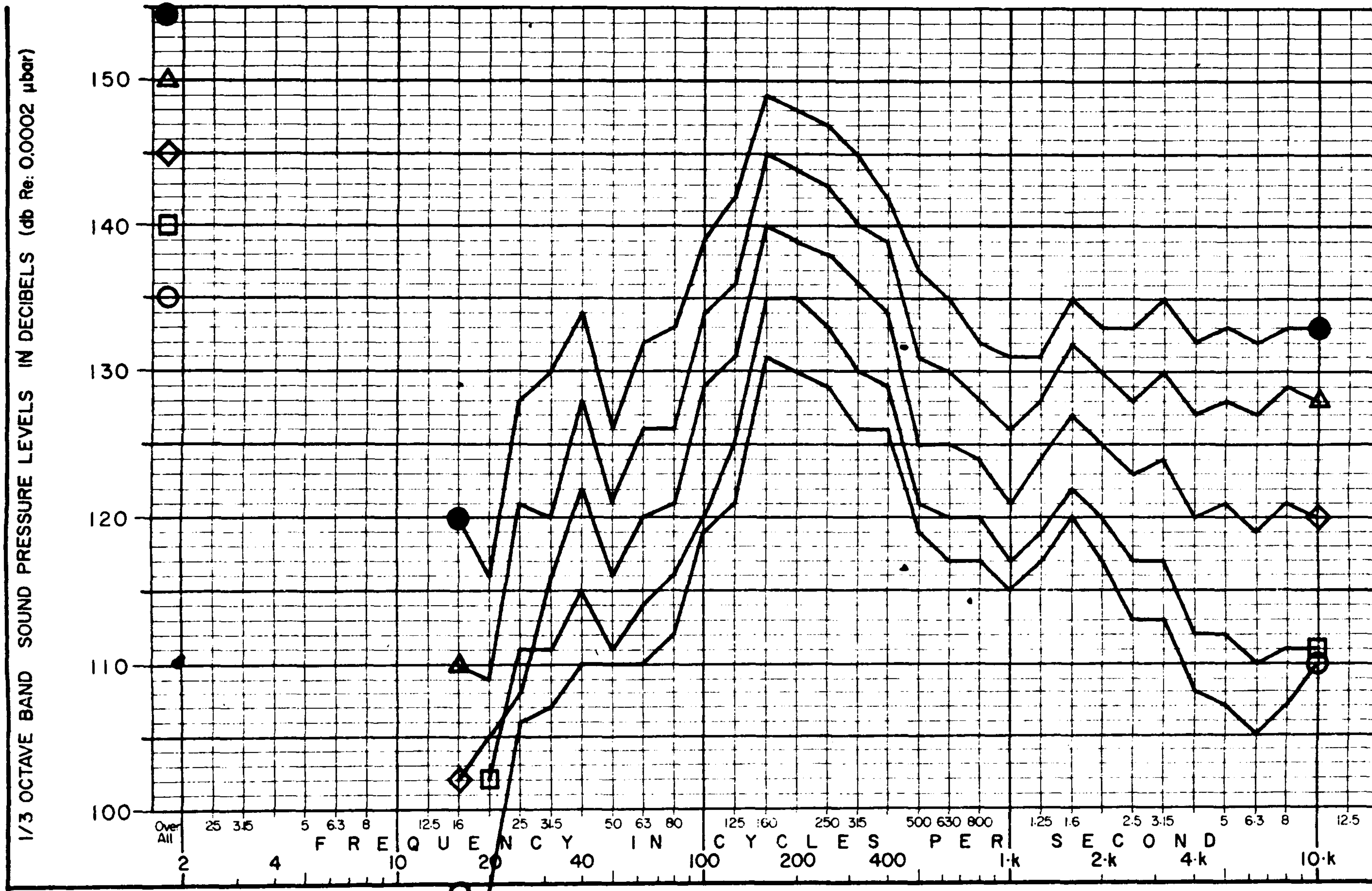


Figure B-0.2



DENVER TEST FIXTURE

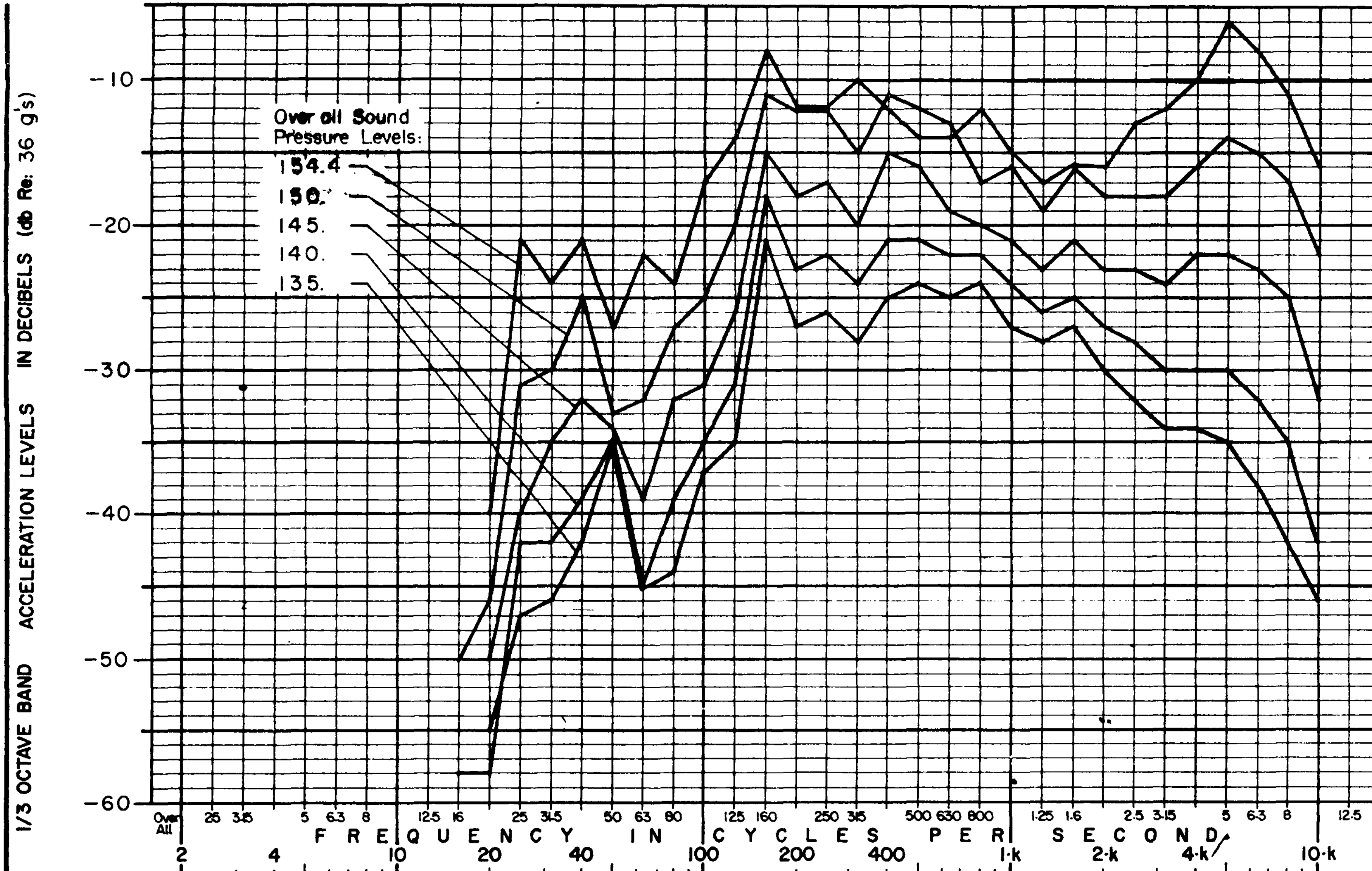
FIGURE B-0.3



SYMBOL LEGEND

RUN 18
DENVER DATA
MICROPHONE 2

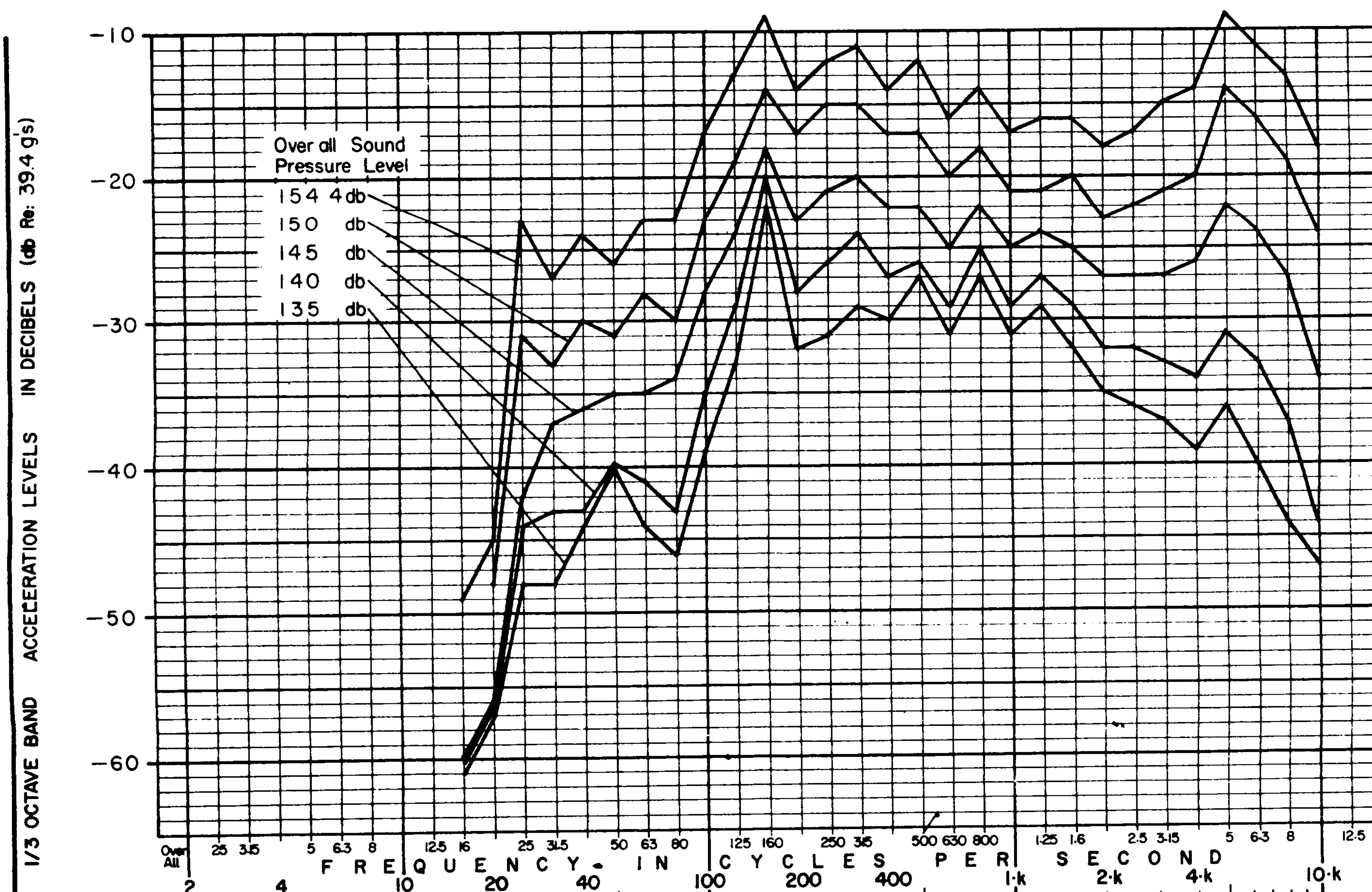
FIGURE B-18.1



SYMBOL LEGEND

RUN 18
DENVER DATA
ACCELEROMETER 3

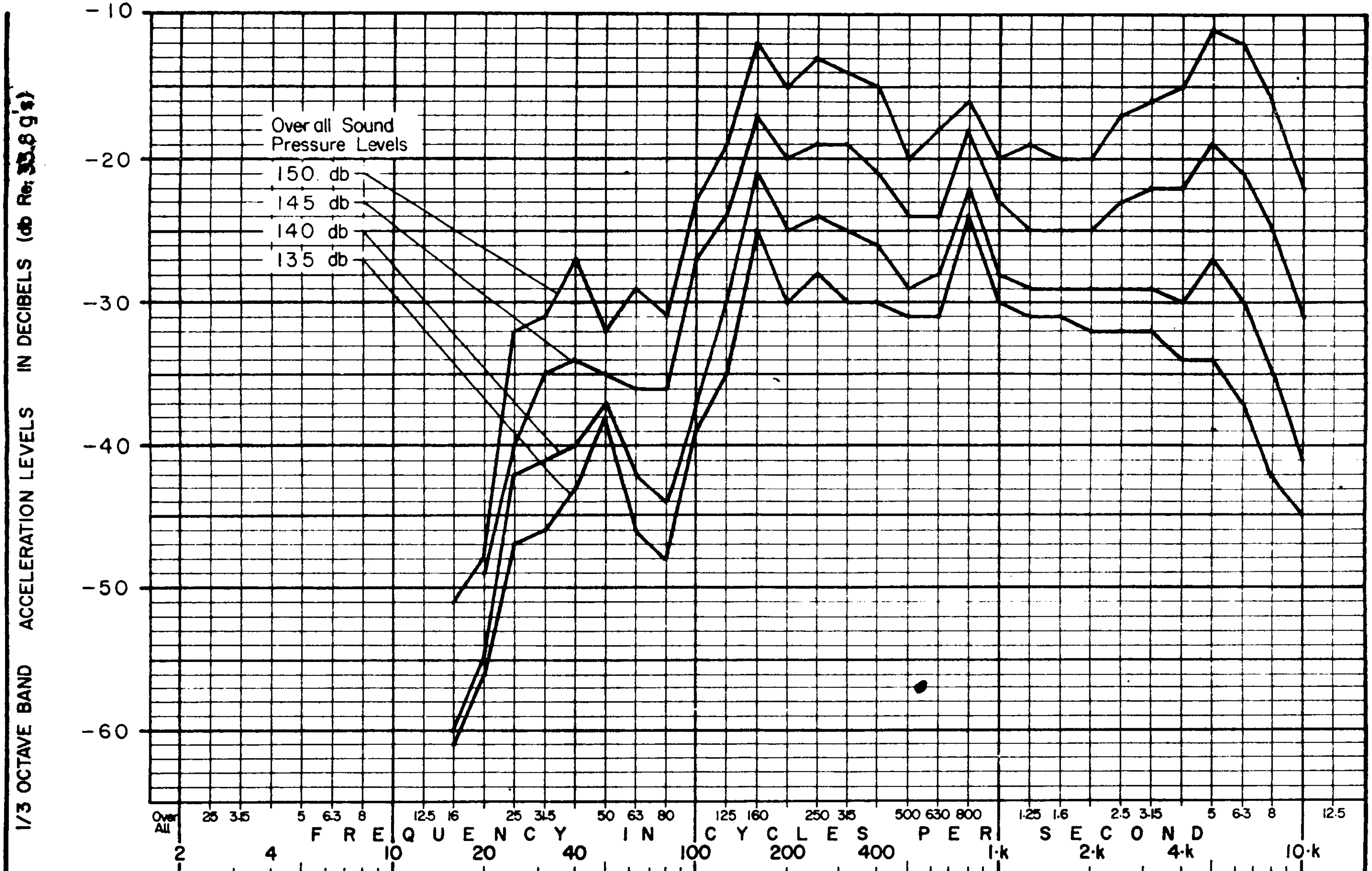
FIGURE B·18.2



SYMBOL LEGEND

RUN 18
DENVER DATA
ACCELEROMETER 2

B-18.3
FIGURE



SYMBOL LEGEND

RUN 18
DENVER DATA
ACCELEROMETER 4

FIGURE B-18.4

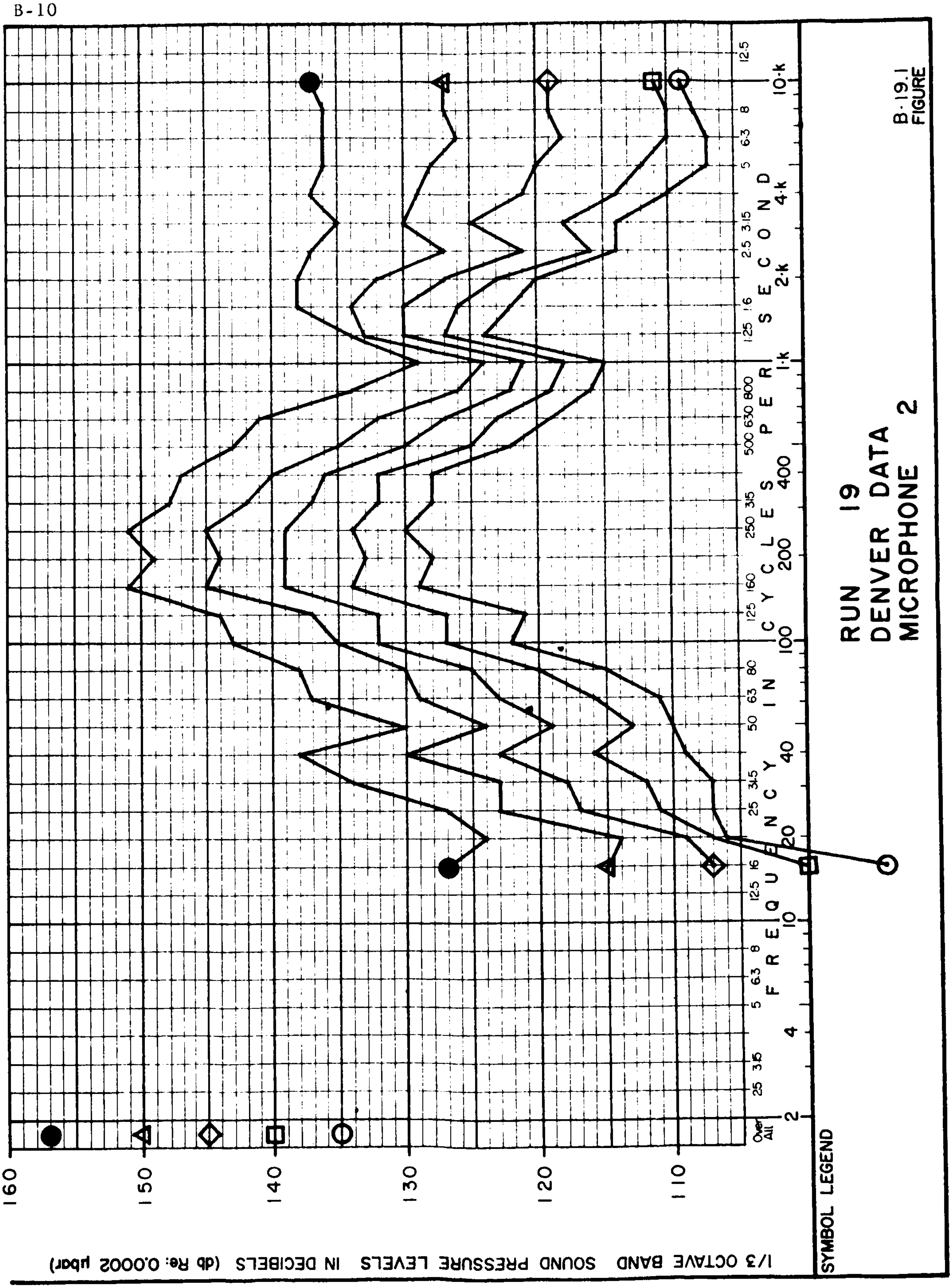
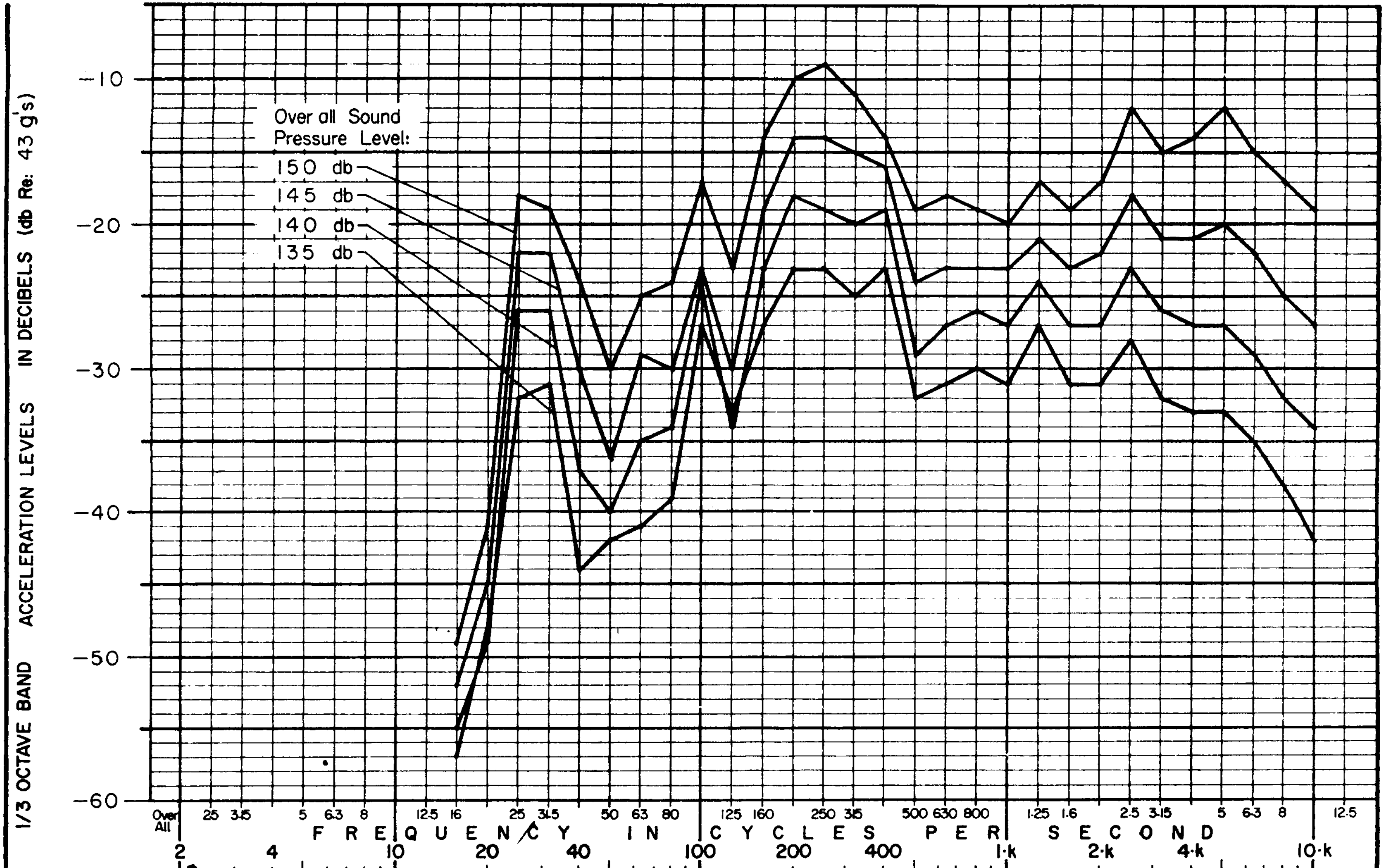

1/3 OCTAVE BAND SOUND PRESSURE LEVELS IN DECIBELS (db Re: 0.0002 μbar)
160
150
140
130
120
110
FREQUENCY IN CYCLES PER SECOND
Over All
2
2.5
3.15
4
5
6.3
8
10
12.5
16
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1·k
1.25
1.6
2·k
2.5
3.15
4·k
5
6.3
8
10·k
12.5
SYMBOL LEGEND
RUN 19
DENVER DATA
MICROPHONE 2

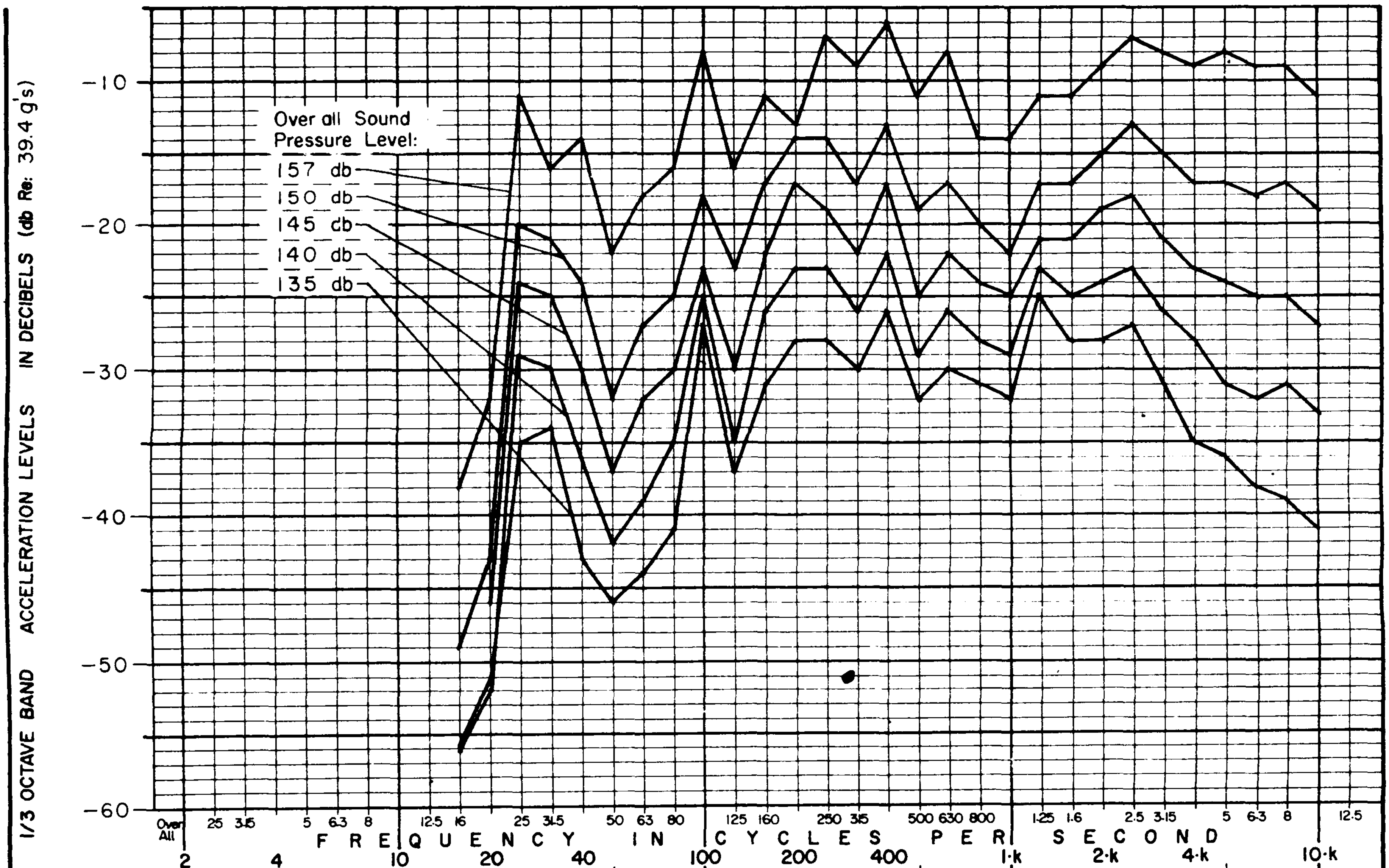
FIGURE B-19.1



SYMBOL LEGEND

RUN 19
DENVER DATA
ACCELEROMETER I

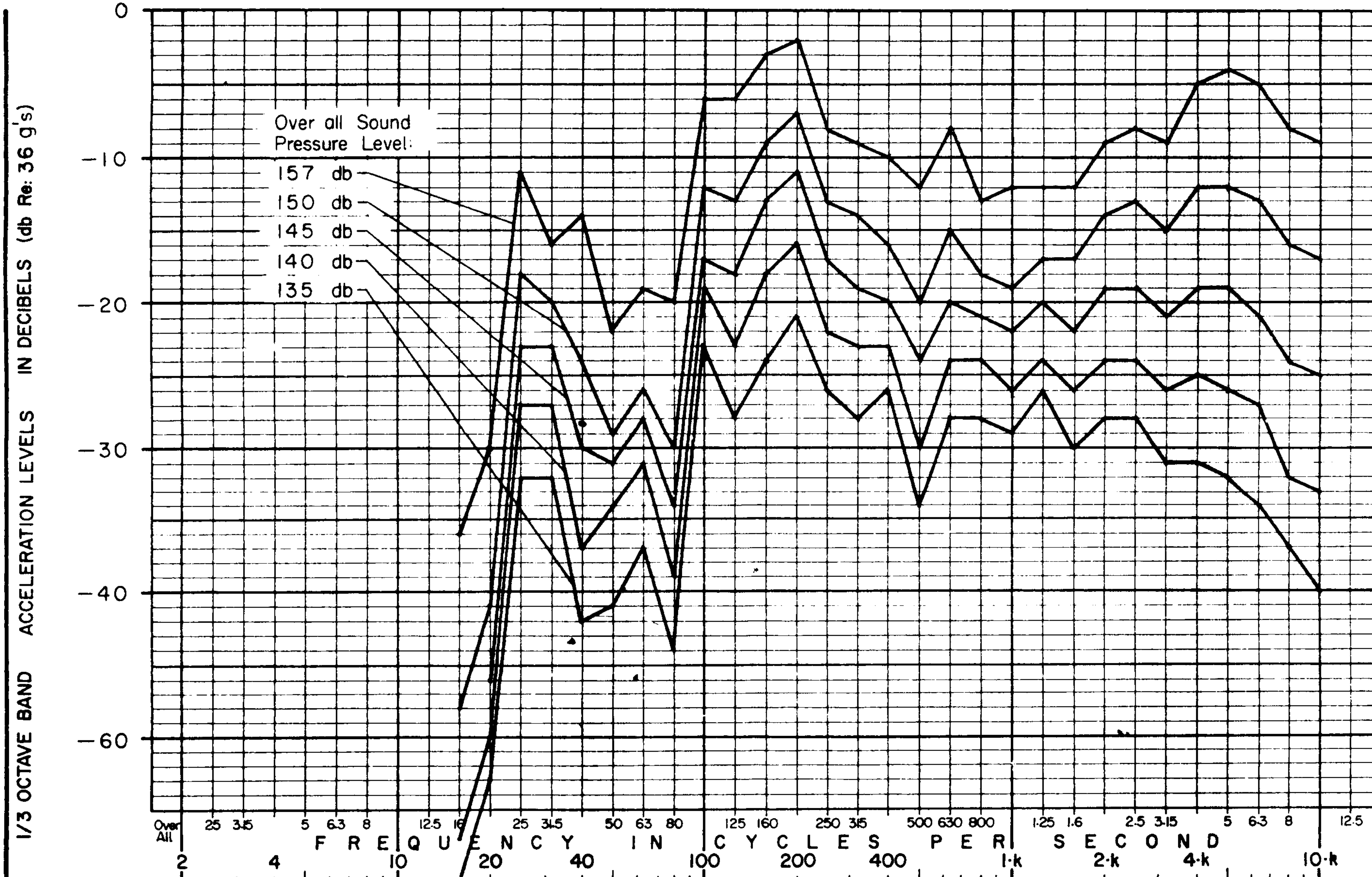
B-19.2
FIGURE



SYMBOL LEGEND

RUN 19
DENVER DATA
ACCELEROMETER 2

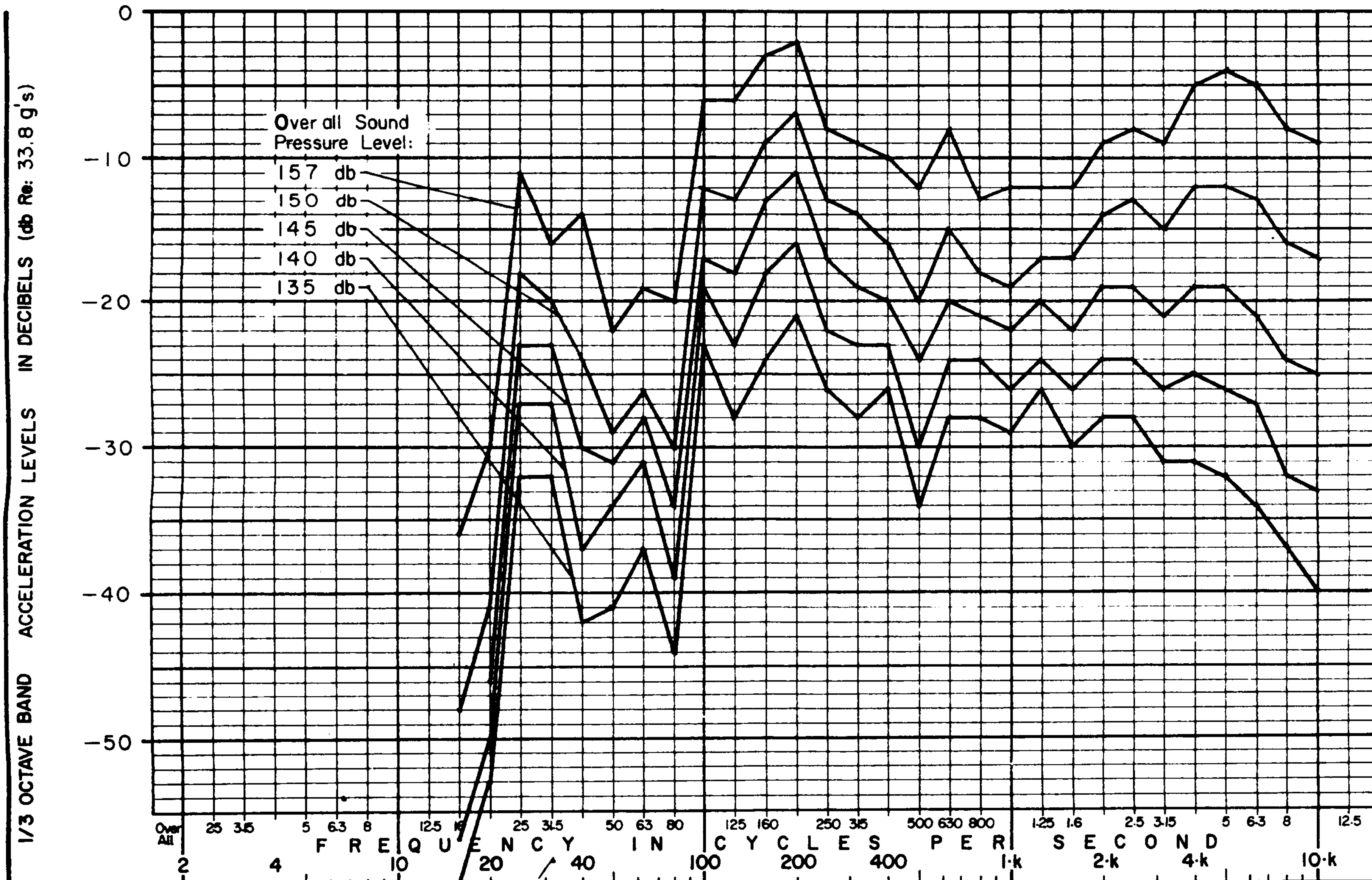
B-19.3
FIGURE



SYMBOL LEGEND

RUN 19
DENVER DATA
ACCELEROMETER 3

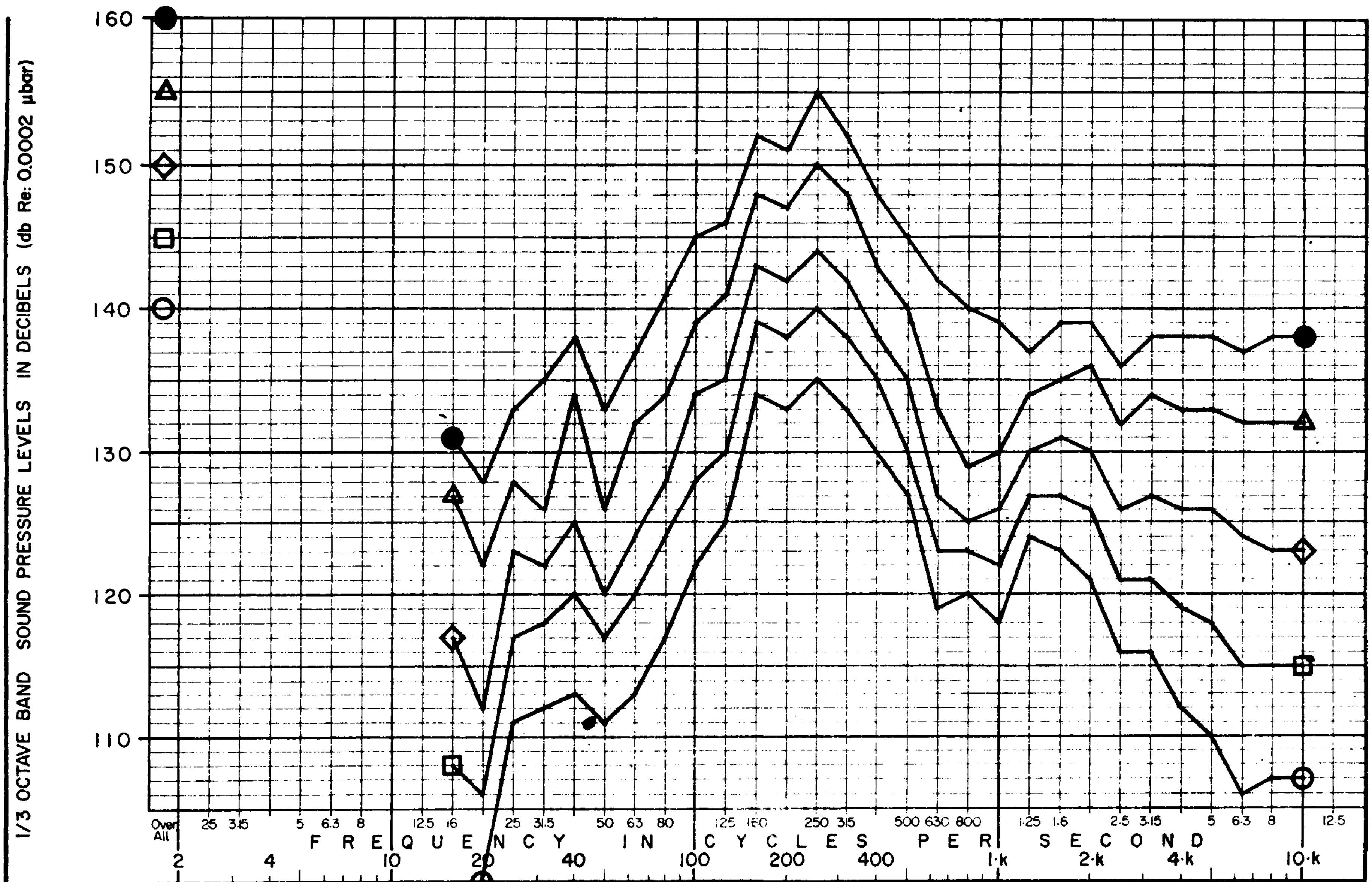
B-19.4
FIGURE



SYMBOL LEGEND •

RUN 19
DENVER DATA
ACCELEROMETER 4

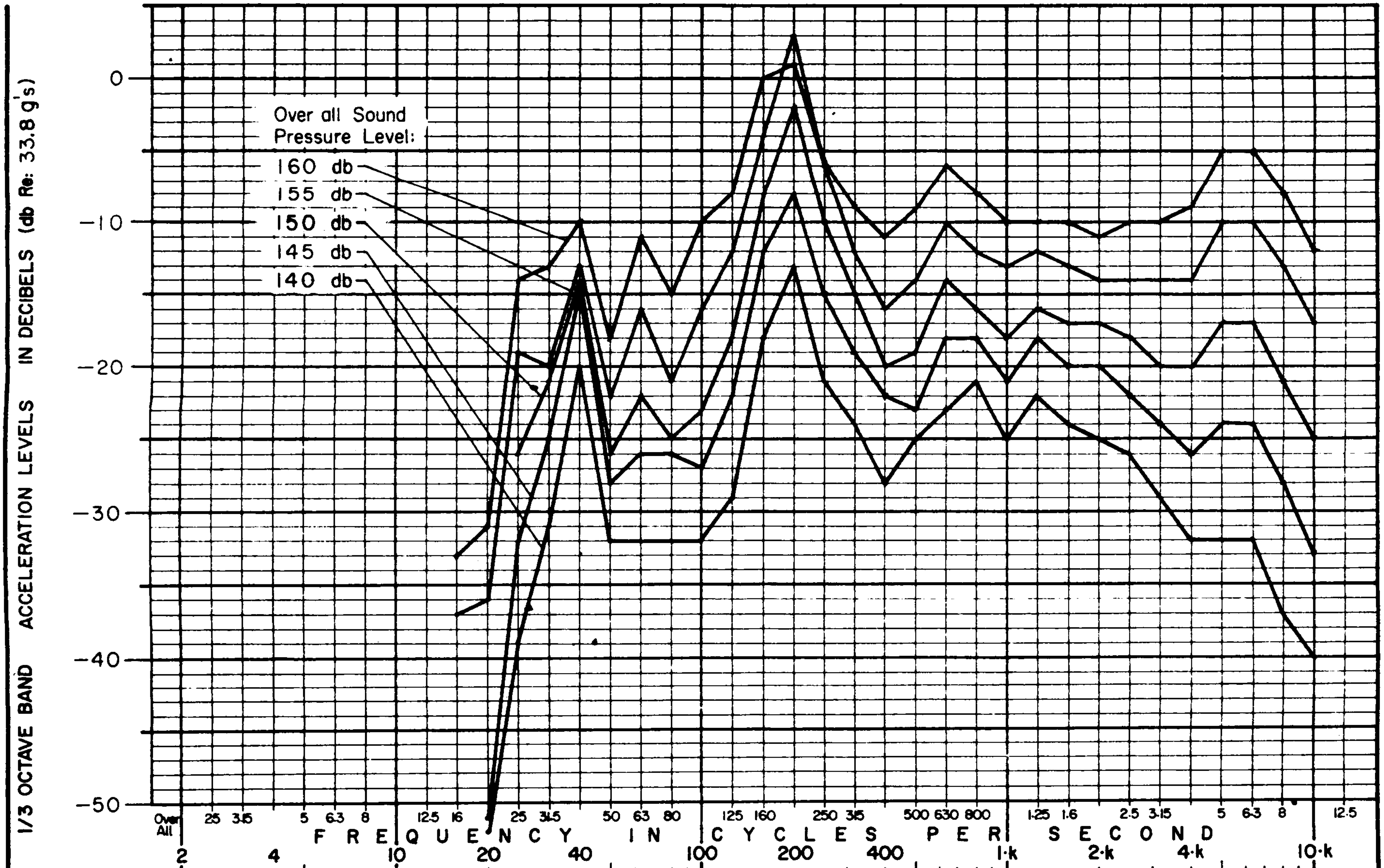
B-19.5
FIGURE



SYMBOL LEGEND

RUN 20
DENVER DATA
MICROPHONE 2

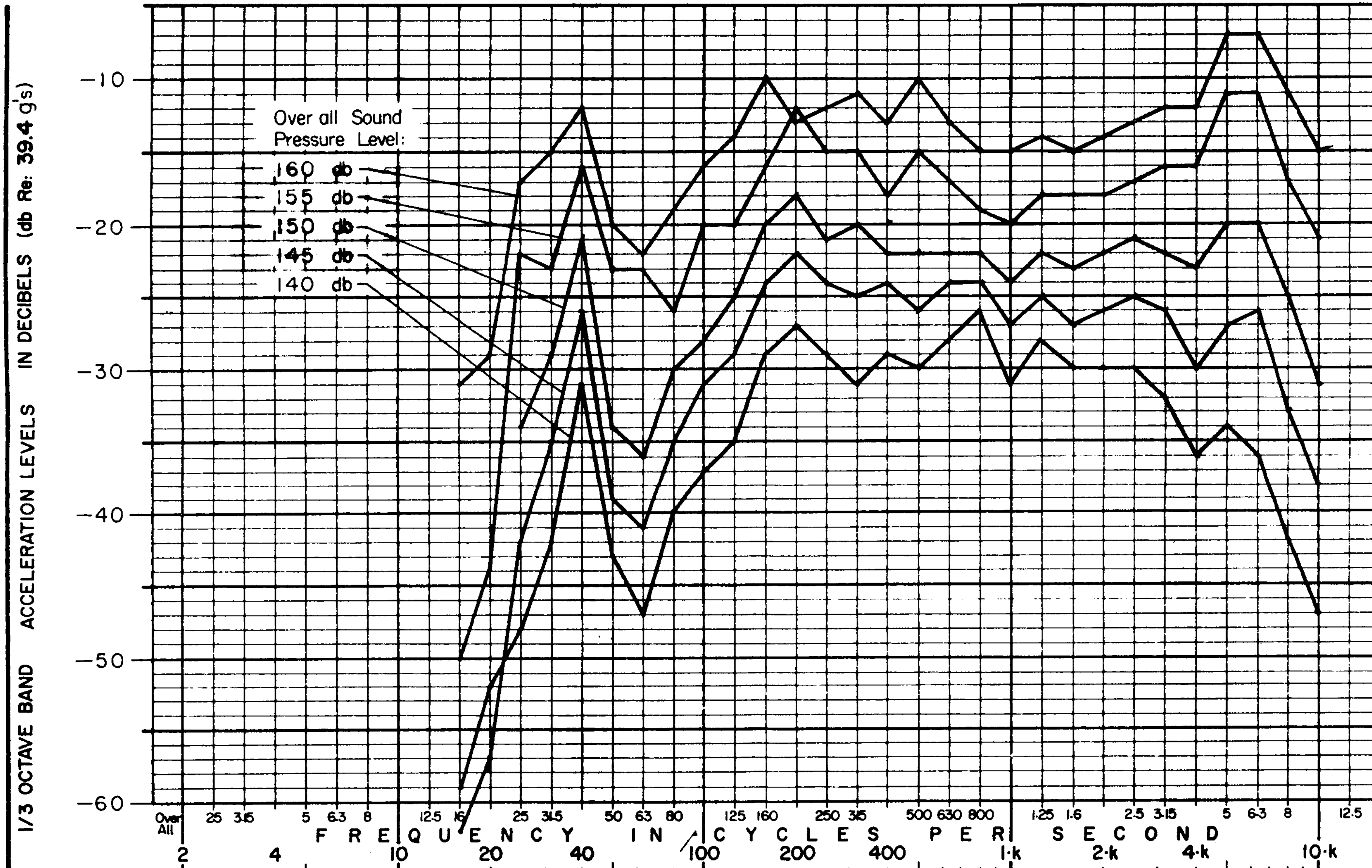
FIGURE B-20.1



SYMBOL LEGEND

RUN 20
DENVER DATA
ACCELEROMETER 4

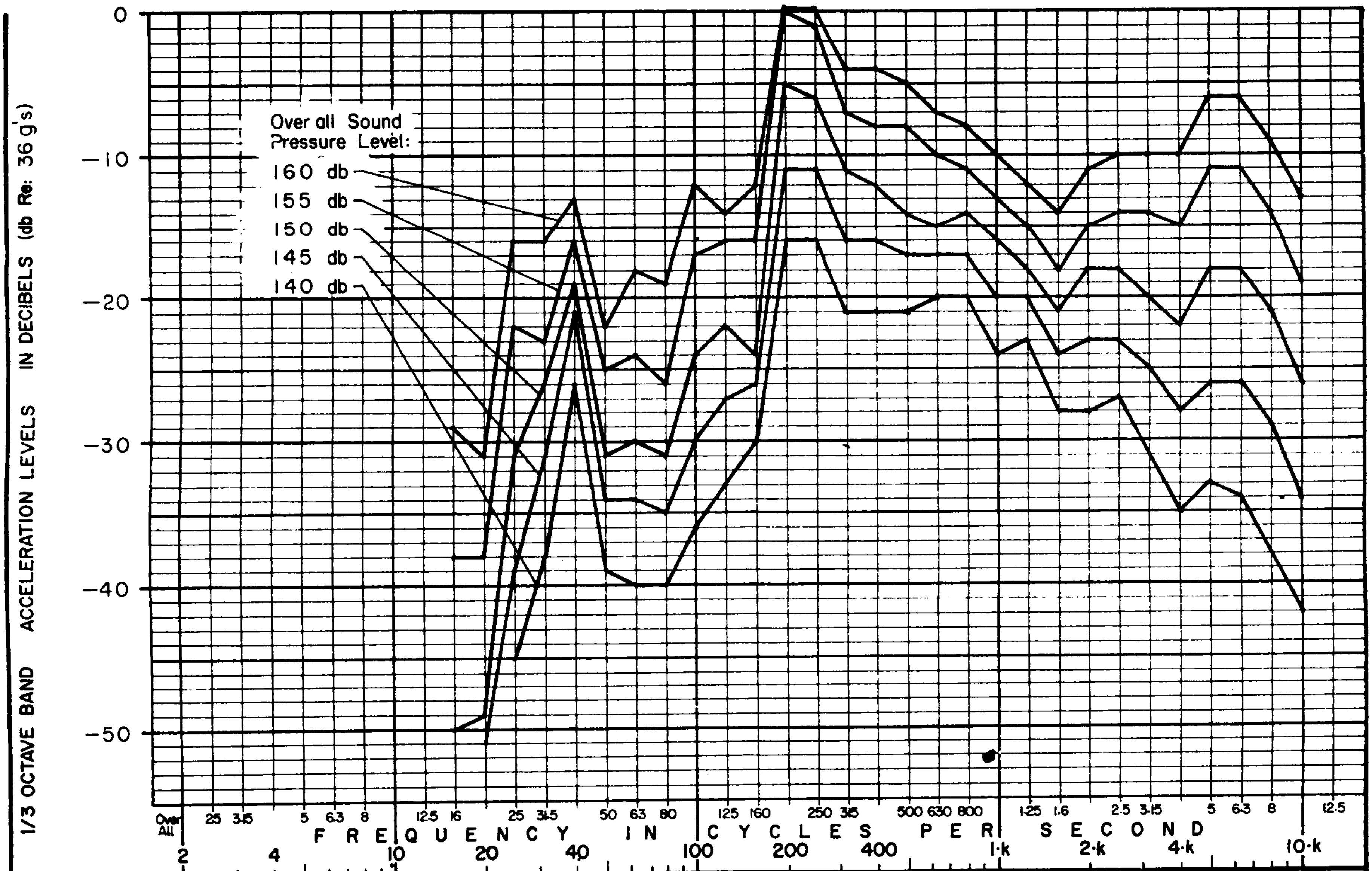
FIGURE B-20.2



SYMBOL LEGEND

RUN 20
DENVER DATA
ACCELEROMETER 2

B-20.3
FIGURE



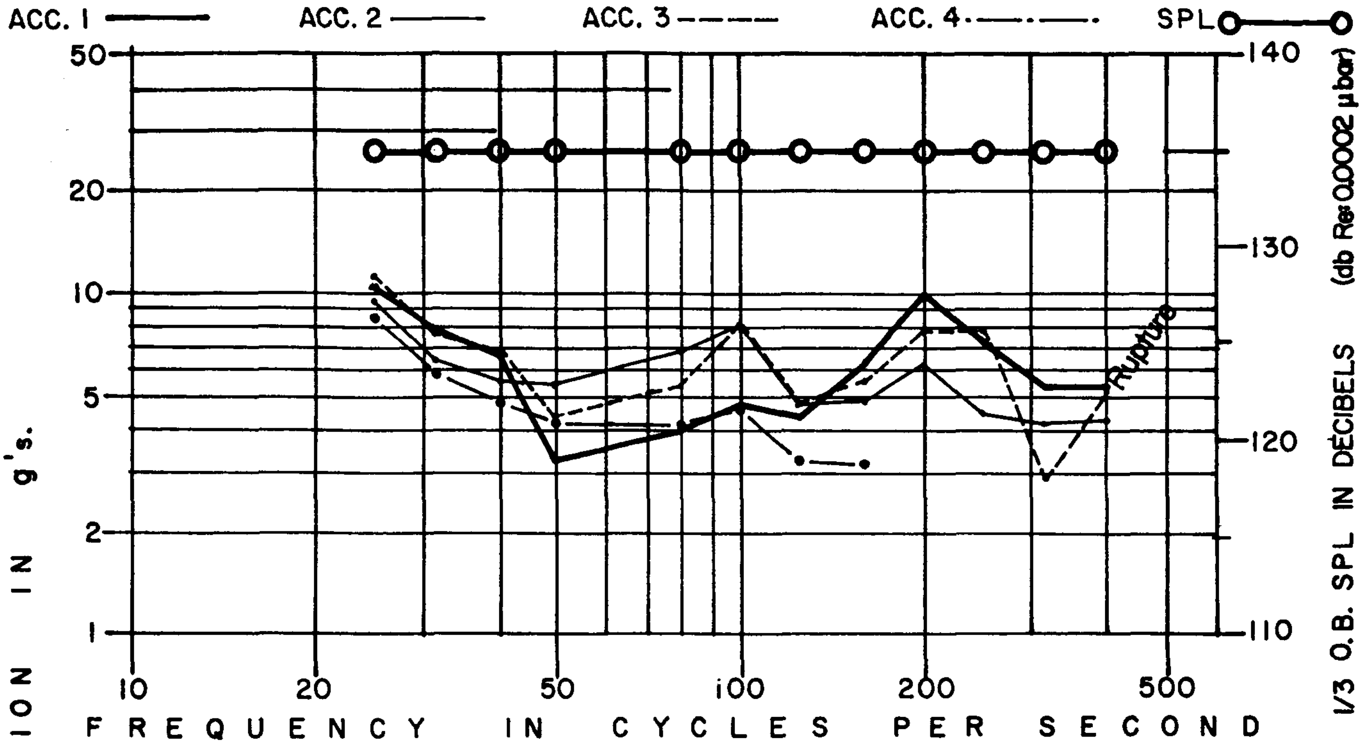
SYMBOL LEGEND

RUN 20
DENVER DATA
ACCELEROMETER 3

FIGURE B-20.4

FIGURE B-21

DENVER DATA
RUN 21



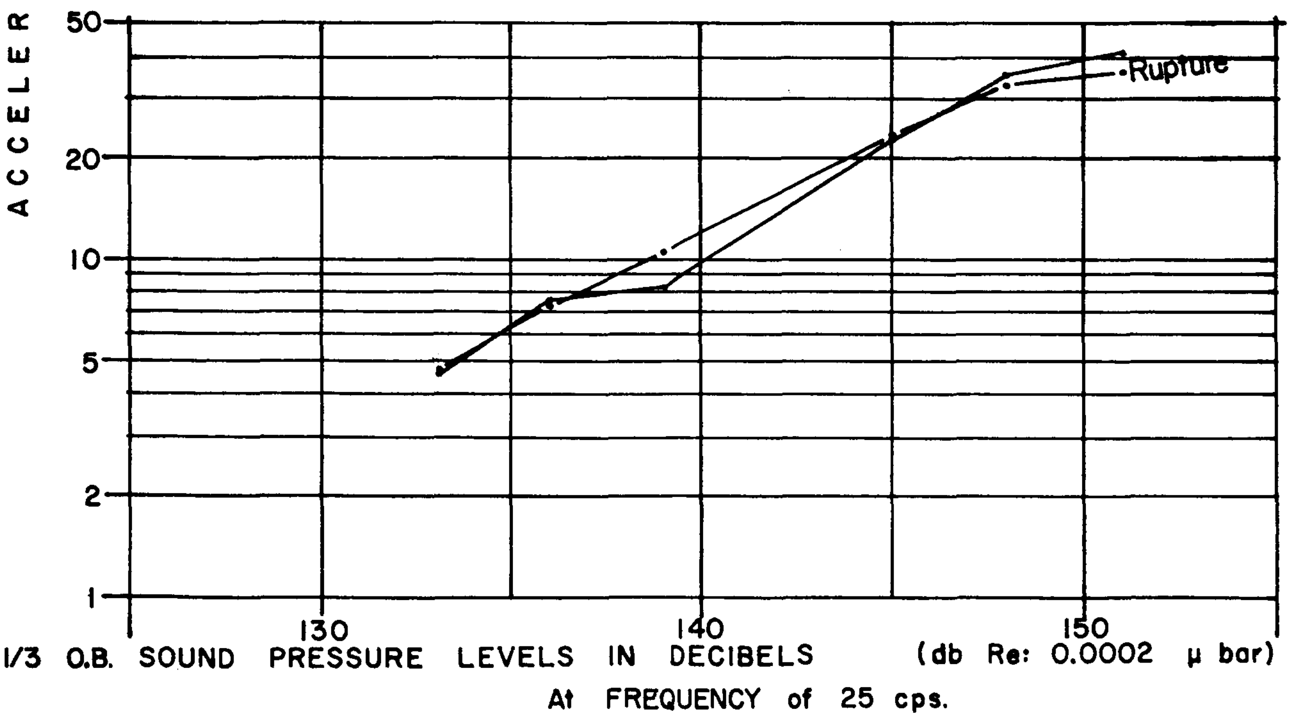


FIGURE B-22
DENVER DATA
RUN 22

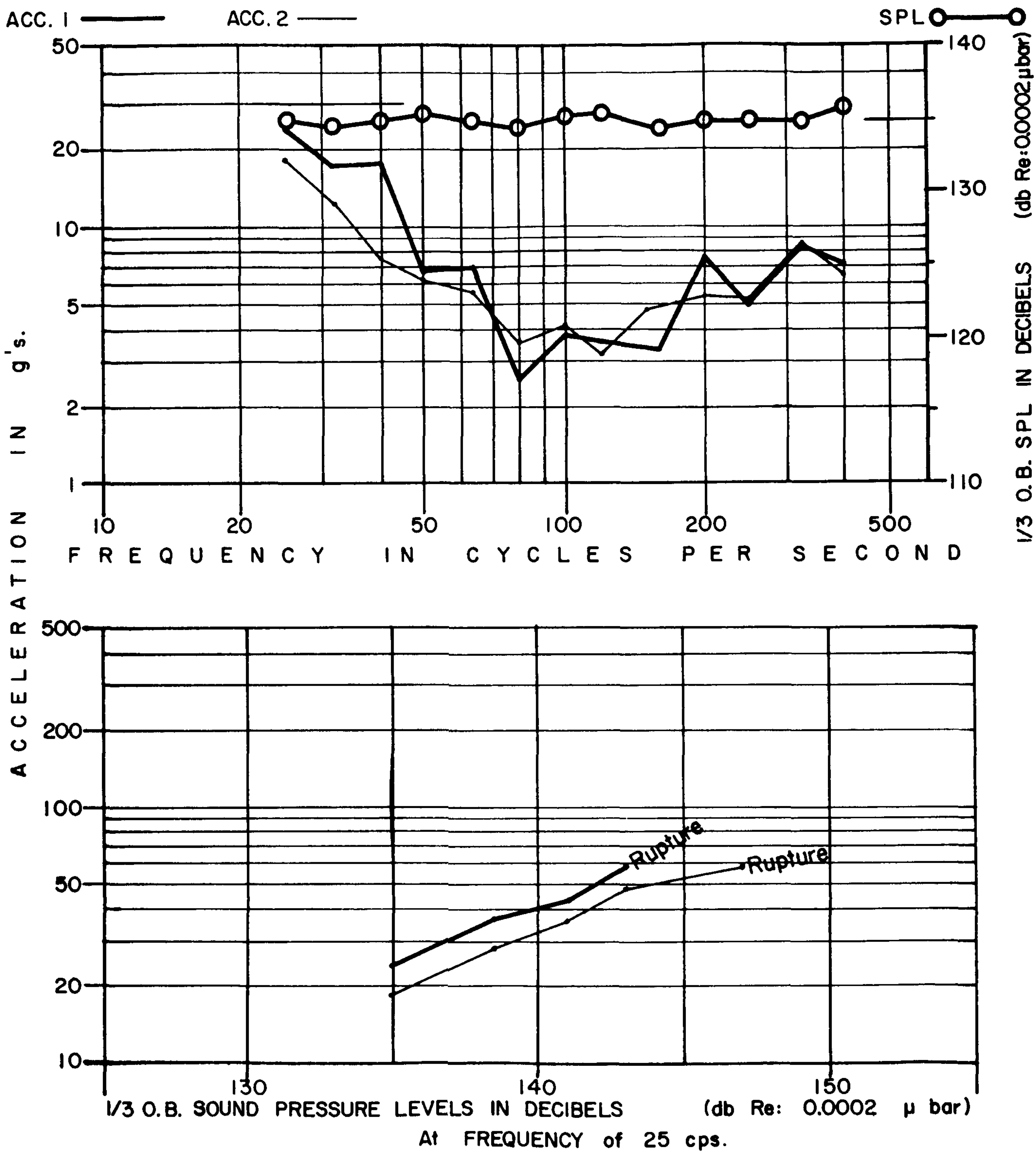
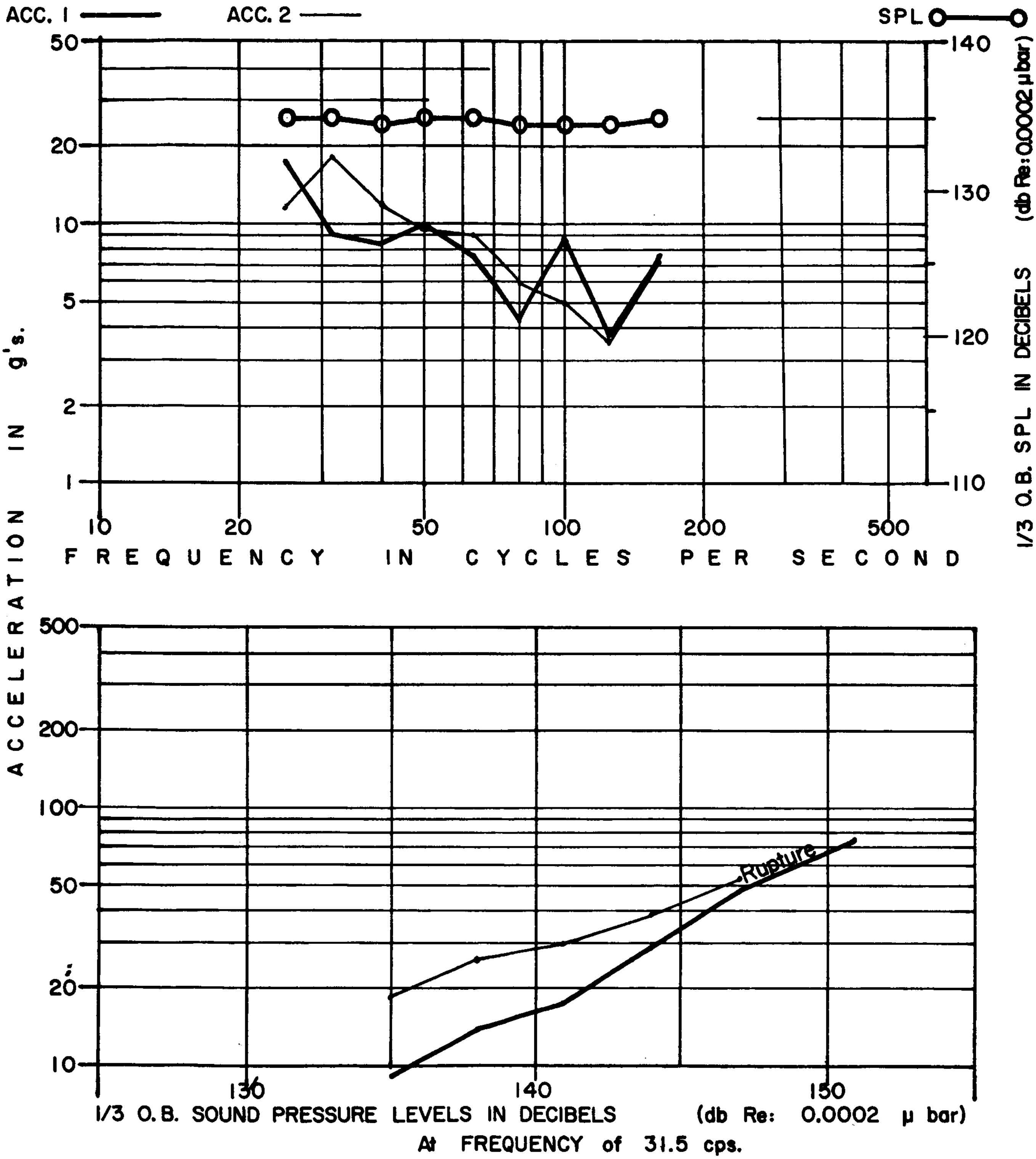


FIGURE B-23

DENVER DATA
RUN 23

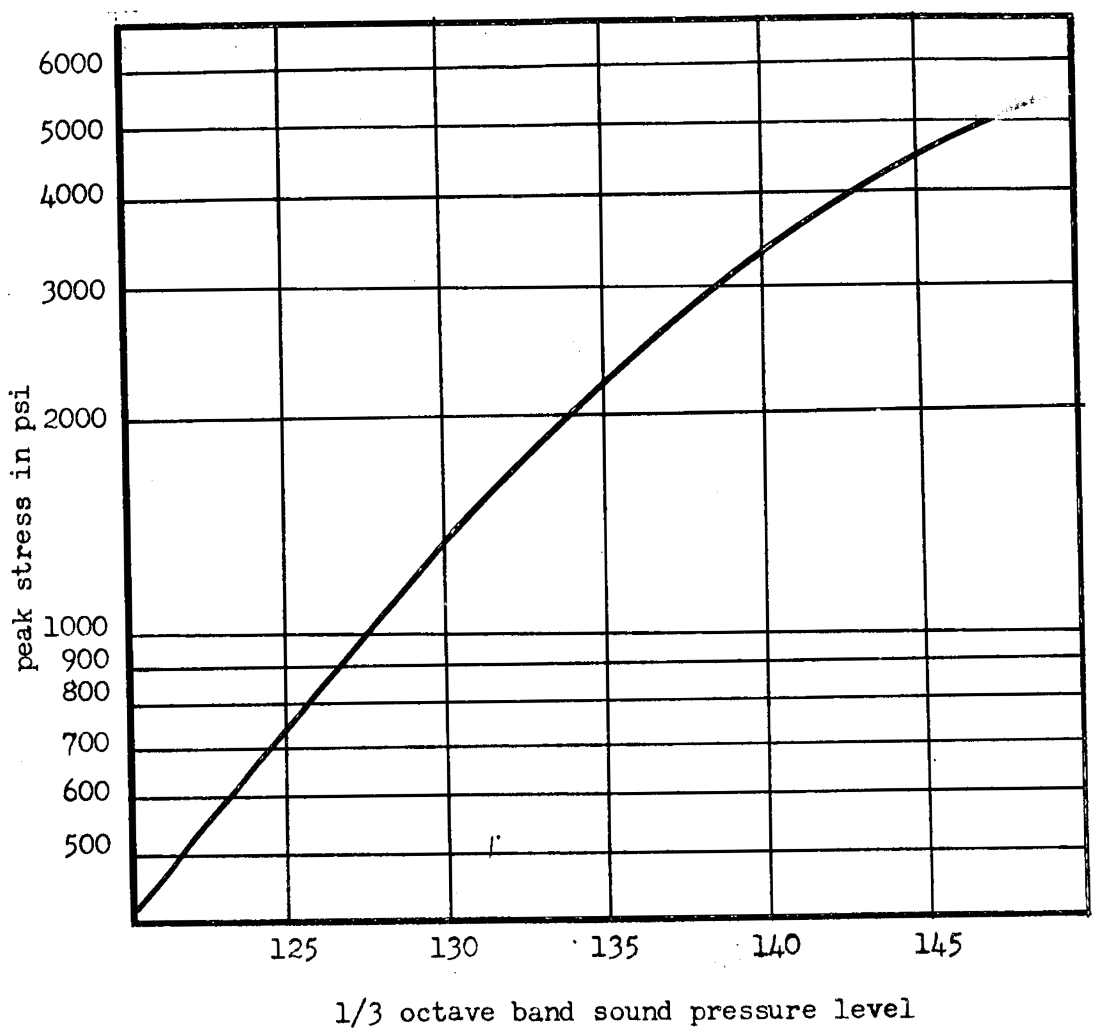


APPENDIX C

FRAGILITY PREDICTION

Prediction of Fragility Level

The fragility of windows to acoustic excitation was determined at the fundamental frequency of the window by test. The fragility above the fundamental frequency was determined by the following method. The stress at the fundamental frequency was determined from the following graph.



Sinusoidal data at resonance were corrected for random, 1/3 octave level. The stress levels at other frequencies were found from acceleration data. From the graph, the stress at frequency f_1 (f_1 f_0) was located on the curve. The increase in sound pressure level (SPL) required to increase the stress to 5000 psi (the assumed failure stress). The fragility SPL was the sum of the test SPL + SPL. As an example, assume the stress at 200 cps was 740 psi. The excitation required to raise 750 psi to 500 psi would be 22 db. If the excitation level was 145 db (135 db sine -7 db sine-random correction +17 db bandwidth correction) the fragility level would be 167 db (1/3 octave band SPL).

The following table shows the fragility predictions for each window.

Run 1		Run 2		Run 3		Run 4	
Freq.	Fragility Level	Freq.	Fragility Level	Freq.	Fragility Level	Freq.	Fragility Level
23.5	142	25	142	24	142	25	142.5
30	152	30	146.5	30	144.5	30	144.5
39	152.5	33	143	32	143.5	31.8	143
41	155	35	143.5	32	142.5	33	142
45	156	40	149.5	35	146.5	35	145
50	159.5	50	154	40	151	40	149.5
60	163.5	60	160	50	156.5	50	156.5
70	165.5	68	161.5	60	159	60	160
76	175	75	167.5	66	161.5	70	161
98	182.5	80	172	76	167.5	77	171.5
120	187.5	100	173.5	100	171.5	100	172.5
140	192	120	176.5	112	174	120	178.5
160	192.5	140	178.5	120	178.5	140	181.5
182	192	160	181	160	183.5	160	183
250	197.5	180	185	165	184	180	188.5
300	203			180	184	190	191.5
350	204.5			180	184.5	200	181
400	209.5			200	181	280	198
450	213			230	185.5	395	200
490	212.5			280	197	450	201
495	209.5			320	195.5	480	198.5
560	213			360	203	575	208.5
				440	203.5		
				485	205.5		
				550	212		

Run 5

Freq.	Fragility Level
25	150
30	145
31	142
31.5	146.5
35	154
45	160.5
50	163.5
60	167.5
70	170
76	171.5
80	174.5
90	178.5
100	182
120	186
140	189
160	190.5
180	192
186	193
280	197
320	203.5
450	218.5
500	214.5
560	209.5

Run 6

Freq.	Fragility Level
25	146
26.8	142
30	150.5
30	148.5
33	151.5
33	153.5
35	154
35	152
40	156
50	163
50	162.5
60	166.5
68	170
68	171
76	173.5
80	173.5
80	174
80	173.5
80	174
100	180
120	187
140	189.5
160	191
240	199
280	210
360	211
400	211.5
450	215.5
520	216.5
550	219.5

Run 7

Freq.	Fragility Level
25	142
30	149.5
35	152
40	154
42.5	152
42.5	150
50	161.5
60	164.5
69	165
76	166.5
80	168
85	162.5
85	163
100	175.5
120	176
140	181
160	181.5
180	188.5
190	183
200	188.5
200	188
257	187
280	193
360	200
400	204.5

Run 9

Freq.	Fragility Level
25	146.5
30	149
35	142
40	149
45	152.5
50	155.5
60	158
70	163
77	166.5
80	167
90	170.5
100	173.5
120	175.5
140	179
180	181
192	181.5
200	178.5
280	197
400	204
450	205.5

Run 12

Freq.	Fragility Level
25	142
45	150.5
45	153
50	154.5
60	159.5
67	162
77	165
80	166
90	169.5
100	172
120	175
160	184.5
180	184
200	186
200	186
240	192.5
280	197.5
320	197
360	204
400	201.5
450	202
500	208
560	209

Run 14

Freq.	Fragility Level
45	142
50	147
55	153
60	152.5
68	156
77	157.5
80	159.5
90	160.5
100	164
120	167
140	171
160	173.5
180	174
200	174
240	182.5
280	187.5
320	188.5
360	192
382	190
400	189
450	196
500	196.5
540	197

Run 15

Freq.	Fragility Level
54	145.5
50	142
55	145
60	147
66	151.5
76	156.5
80	157.5
90	161
100	162.5
120	167.5
160	173.5
180	173.5
200	176.5
280	183.5
320	182
320	183

Run 16

Freq.	Fragility Level
35	147
40	142
45	147.5
50	150.5
55	150
60	152.5
67	155.5
75	160.5
80	161.5
80	162
90	166
90	166
100	166.5
100	167
120	171.5
120	172
140	170
140	171
140	171.5
160	178.5
160	179
280	189
280	190
320	194
360	198
360	199
400	202.5
450	201.5
450	202.5
500	206
540	203.5
540	204

Run 17

Freq.	Fragility Level
45	142
50	143
55	145
60	142
60	149
65	145.5
65	147.5
73	157
80	161.5
90	163
100	165.5
120	170.5
140	171.5
160	174.5
160	175
180	174
194	172
194	172.5
200	173.5
200	171.5
200	172
220	173
220	174
240	180
280	186
400	189.5

Run 18

Freq.	Fragility Level
25	142
31	144
40	154
50	159.5
62	165.5
80	166.5
100	178.5
125	178
160	185
200	191
250	194
315	199.5
400	196

Run 19

Freq.	Fragility Level
16	146.5
20	142
25	153
31	158.5
40	156
50	164
62	165
80	165.5
100	181.5
125	187
160	201
200	189.5
250	194
315	201
400	205

Run 20

Freq.	Fragility Level
25	142.5
31	142
40	154.5
50	156
62	160.5
80	172
100	181
125	182.5
160	176.5
200	183
250	198
315	205.5
400	212

Run 21		Run 22		Run 23 Acc #1		Run 23 Acc #2	
Freq.	Fragility Level	Freq.	Fragility Level	Freq.	Fragility Level	Freq.	Fragility Level
25	142	25	142	25	142	25	141.5
31	150	31	150	31	153	31	142
40	156.5	40	156	40	159	40	152
50	167	50	168	50	162.5	50	158.5
62	169.5	62	172.5	62	169	62	161.5
80	175.5	80	186	80	179	80	172.5
100	178.5	100	188.5	100	178	100	178.5
125	184	125	193	125	190	125	186.5
160	186.5	160	198.5	160	189	160	186
200	187.5	200	196.5				
250	194.5	250	204.5				
315	202	315	205.5				
400	207	400	211.5				

APPENDIX D

MOTION PICTURE CONTENT OUTLINE

MOTION PICTURE CONTENT OUTLINE

"SOUND OF THE FUTURE"

OBJECTIVE	Public Information and Orientation
TREATMENT	Credulity is the key. The best approach here is to take dead aim at the audience and design the picture specifically to explain. People seldom fear, resent or are apprehensive about anything of which they understand or have some knowledge. We can utilize a soft sell approach, but at no time will we talk down to the audience. Therefore, the base line for design would be to inform the public, specifically those communities nearest the large booster launch sites, of the intense noise levels that they might expect during the launch of Saturn V and post Saturn boosters.
BASIC OUTLINE	PART I - Sound as a Part of Our Daily Lives PART II - NASA Planning for Noise PART III - Human Reaction to Noise PART IV - Conclusion
GENERAL	This will be a 16mm color sound motion picture presentation of approximately 12 minutes, 45 seconds. The picture must be believable, adhere to authenticity and take every precaution against the possibility of insult to audience intelligence or knowledge of the subject matter.

I. INTRODUCTION: SOUND AS A PART OF OUR DAILY LIVES

VISUAL	AUDIO
1. The opening scenes will be a cut	FX sound cue
Pace montage to depict	
Pleasure	Dance music
Fear	Scream
Emotion	Woman crying
Distress	Baby crying
	(FX sound under)
Dissolve	
2. Busy street scenes	The sounds you have just heard are familiar sounds....the routine sound that is a part of our daily lives.
Dissolve	Narrator continues
3. NASA stock Pre-launch Mercury VII cut to last-minute prep of astronaut in capsule. Pace fast. Cut to	However, today we live in an age of new ideas where the sum total of human knowledge is growing....and
4. NASA stock. Continue pace - Pre-launch - Block-house - communications - red flashing light, etc.	(FX sound autohorn, etc. on cue) Narrator continues This new knowledge produces new sounds
Cut	(FX sound under narrator)
5. NASA stock - ignition	Sounds that are unusual....but
Cut	
6. NASA stock - launch	So are the requirements! Narrator out
7. Super presentation title over lift off. Continue on to track "THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION PRESENTS"	FX sound taken from data tapes. Noise levels will be extremely loud just after lift-off.
(Hold for Reading Time) Fade	Continue FX sound and take it down as booster climbs.
Super main title "SOUND OF THE FUTURE" over NASA stock taken from capsule. Fade	Bring in theme music and build through main title.

	VISUAL	AUDIO
		Narrator
8.	Simple limbo set - Sync narrator on camera - violinist in background. Camera starts move.	All the sounds you have just heard were produced by the vibration of air....
9.	Sync - Narrator turns as camera moves in to MCU of violinist picking.	A simple example is a vibrating string of a violin which produces pressure fluxu-ations in the air.
10.	Sync - MCU as violinist goes into some music.	The vibrating air in turn vibrates the ear and is then interpreted by the brain as music.
11.	Cut to	The two major properties of sound are.... frequence....and....amplitude.
12.		Amplitude is associated with loudness. (FX sound) and...... frequency with tone. (FX sound).
13.	MCU - String Bass	Narrator continues. A low pitch tone....such as one produced by a string bass (FX sound).....is of a low frequency and....
14.	CU - Oscelloscope	has a long wave length....
15.	MCU - Flute	whereas a note of the flute is a high frequency tone (FX sound)....with
	CU - Oscelloscope	a short wave length.
16.	CU - Tuning fork	A few sounds, such as a note from a tuning fork (FX sound) contain only one frequency and are called pure tones.

Visual	Audio
17. Stock - Dance band or girl with radio.	Most musical sounds contain several pure tones....mixed to produce a desired sound.
18. Jet airliner starts to taxi turning into	Jet engines (FX sound) contain all frequencies within a certain range with some frequencies louder than others.
Full screen - Continue turn to runway and after-burner blast.	This type of sound is called.... random noise.
19. Stock - CU of rocket engine. Possibly cut in some diagramic art.	(FX sound as required.) Rocket engine noise is produced by high velocity jet exhaust gases....The shear layer formed by the jet, and the surrounding atmosphere produces turbulent fluctuations which in turn produce random noise.
Re-establish engine.	
20. Stock - CU of a larger engine - ignition.	(FX sound) As rocket engines get larger... the noise gets (Build on FX)
21. Launch	louder and more low frequency noise is produced. (Continue to build on FX)
22. Lift Off Track	This noise is highly directive....and as a result, a person standing some distance from a launch will hear the loudest noise when the booster is in the air.

II. PLANNING FOR NOISE

Visual	Audio
23. Street Scenes - Florida	This brings the problem closer to home... to you.....

VISUAL	AUDIO
24. NASA Stock. General Aerials Cape	Launch sites have been carefully laid out at the Cape Kennedy Facility to best utilize the available land and with the best interest of the community in mind....
NASA Stock. Long shot of Saturn on pad.	However the use of larger rockets have created sufficiently high noise levels to offset further spacing of the launch areas. And....
25. NASA Stock. Saturn Prep for static firing full screen of pre-fire activity in engine compartment.	As a result....some of the larger thrust booster launch sites have moved nearer to community areas..... (FX sound on cue)
Ignition and run of above - good engineering footage. Dissolve	Unfortunately....despite all efforts to avoid it....the new larger rockets will create higher noise levels than at present.
26. Conference Scenes. Photoplay - several NASA people talking over map of the general area. Good ident of at least one area showing relationship to the Cape. - Cut to some street scenes or recreation areas of the same point.	As part of the planning for these launch sites....the National Aeronautics and Space Administration has taken every precaution to assure as little interruption of community life as possible. But.... minor irritations such as an occasional broken window....and annoying noise are to be expected.
27. Cutaway - Artist's concept of Saturn V Cut to	Rocket engine noise has caused minor problems for missile and space designers in the past.
28. Artist's concept of Saturn V launch.	One such problem involved the noise produced by the engines during the first part of the flight.

	VISUAL	AUDIO
29.	Pan up - Art work in Sc. 28.	These problems have been associated with acoustically induced vibration of the vehicle skin which is transmitted to system components. And....
	Extreme close-up of vibration test. (Show break if possible) or possibly use camera effects on art of previous scenes.	without proper protection the vibrations could cause some parts to malfunction.
30.	Stock - Open scene with ring camera shot of engine and then to a montage of launches on cue.	(FX sound as required) Although this same noise could be heard in surrounding communities during the launch of such boosters as Jupiter.... Minuteman....Titan....and Saturn I.... little
31.	Normal family scene in Florida. Possibly backyard barbecue.	attention was paid to it because noise levels were very low. (Down on FX sound).
32.	Stock - Possibly show a launch from air or one of the other pads. Anything to show distance.	The obvious reason was because of the lower engine thrust....
33.	Continue track of Sc. 32.	But, as the boosters become larger, and.... (Cue FX sound)
34.	Area map (in relief is possible)	the noise will become louder..... therein lies the problem......However,
35.	MS - Engineer listening to some date tapes.	based on present technology these noises will not be sufficiently loud or.... their time duration sufficiently long.... to cause any more harm than....

	VISUAL	AUDIO
36.	Art work - "Please Stand By" or actual TV interference cut to backyard conversation.	momentary interruption of daily lives and some minor damage
37.	NASA Ident. Front of building, etc.	But, to be positive, the National Aeronautics and Space Administration initiated a study program to prove this conclusion beyond any doubt.
38.		Its true.....rocket engine noise has been known to cause walls and windows to vibrate. (Much as a heavy truck will do).
39.		Walls and windows vibrate at many frequencies. However, the highest vibration occurs at the lowest frequency of vibration....termed the fundamental frequency.
40.	Diagramic art	Thus.....the high amplitude....low frequency sound......easily vibrates a house structure. And.....
41.	Damage - broken windows, cracked plaster, etc.	if the noise levels become sufficiently loud the vibration levels become too severe and some damage could result.
42.	MS of test setup (NASA emblem in evidence) Cut to close-up	The NASA study program was conducted in two phases....During the first phase a siren capable of producing.... (FX sound)
43.	of siren.	high pure-tone sound pressure levels at low frequencies was used to conduct tests on.....
	Re-establish test setup and homes.	abandoned homes in the Merritt Island launch area.

VISUAL	AUDIO
44. Continue stock footage.	During these tests the sound used was over twenty times as high as any sound that would be produced in community areas by any rocket engine being planned.
45. Engineers studying data. Cut to no evidence of damage.	High amplitude vibrations were discovered in both windows and walls. But..... there was no damage on any structures.
46. Stock - Lab setup	Additional tests were conducted in a laboratory using random noise. And again.....no damage resulted.
47. NASA Stock Several of these. Set-ups.	Test Structures, using standard windows and frames similar to those present in community areas, were placed and instrumented by the NASA Safety Office, 1200 ft. from the launch stand during consecutive Saturn I launches.
48. Stock footage.	Again.....no damage resulted.
49. Martin Stock. Test set-up to destruction - Cut to engineer on read out.	Finally....a test structure was intentionally tested to destruction....data proved damage occurred at much higher sound producing levels than would occur under any launch condition.
49. Storm clouds, etc.	Weather has a pronounced effect on the propagation of rocket engine noise.
50. Diagramic art.	The most noticeable effect results from changes in the temperature gradient of the atmosphere which can trap and re-direct the sound back to earth.

	VISUAL	AUDIO
51.		To study this problem.....tabulated weather data for several years was obtained from the Air Weather Service.
52.	General scenes - Computers	This data was then placed on digital computer punch cards and programmed into a ray tracing equation to predict sound impingement points.
53.	Possibly a good medium shot of engineer working on the formula.	Next....focusing amplification factors developed by Perkins of the Aberdeen Proving Ground were used to predict amplitudes.
54.	Instrumentation Cut to Area Map	Knowing the acoustic power of the engines.... it was possible to predict the noise levels of a 30 million pound thrust booster from the Merritt Island Launch Area to be on the order of 120 decibels.....these predicted noise levels will occur in nearby community areas.....this
55.	Window Instrument	would produce a similar effect on a window of a wind gust of..... 14 miles per hour
56.	Reprise - Weather	However.....under adverse weather.....this same noise would produce a vibration similar to.....
57.	Reprise - Instrument	a 40 mile per hour wind gust.....But
58.	Instrument - Show time element.	the time of this exposure would be very short.....Something less than 30 seconds.

III. HUMAN REACTION TO NOISE

59. Bring narrator back on camera. Simple black limbo set.	A popular notion among fiction writers is some terrible weapon of the future which causes sound to kill or maim its victim.
60. On camera.	Actually.....sound could cause physical damage.....or even death.....but the intensity of such sound is.....
	many orders of magnitude higher than any human being in community areas would be exposed to during a launch.
61. On camera.	The human body is much better constructed against such forms of excitation than the houses in which we live.
62. On camera.	The low frequency noise produced by rocket engines will not affect the hearing since the ear is sensitive to high frequency noise and is.....
On camera.	much less sensitive to low frequency noise.
63. General scenes. Launch crew.	Launch crew personnel are exposed to noise levels over 10 times those ever experienced in a community, and.....
	these people are still perfectly safe.

IV. CONCLUSION

64. Good medium shot of engine static test.	Noise is defined as unwanted sound. And we would be the first to admit that rocket engines produce a distinctive noise.

VISUAL	AUDIO
65. NASA launch crews.	But those of us who have been privileged to watch the flight of a large booster and....
66. NASA launch crews.	who have heard....and felt....this low pitched noise....realize that this is a phenomenon with which we must live....and there are no known methods of reducing this noise.
67.	We do know....that this noise will cause little damage....except possibly to improperly installed windows....and damage to these will be rare....
68.	this noise will undoubtedly vibrate walls and rattle some windows and dishes....but the time exposure will be short....and the inconvenience small.
69. Astronaut in capsule.	We can visualize only tentatively and vaguely what man in space can do....but this we know....
continue	a space capsule has to be....
Launch of same.	rocket boosted into its environment!
71. NASA Stock. Activity at Cape Possibly on Gemini Pad	At the present time five major space programs are underway or are being planned.
72. NASA Stock. Gemini launch	Gemini.....a two manned orbital mission for space exploration....boosted by a 300,000 pound thrust Titan II.

	VISUAL	AUDIO
73.	NASA Stock. Saturn launch	Saturn I-B....thrust....1,500,000 pounds.... an earth-orbit launch vehicle for Apollo space craft.
74.	Conceptual art or Stock footage of III A	Titan III.....to orbit an experimental laboratory....thrust 2½ million pounds.
75.	Conceptual art	Saturn V.....for manned lunar exploration.... thrust 7,500,000 pounds. And.....
76.	Conceptual art	Post Saturn.....with 35,000,000 pounds of thrust will be used for manned Mars exploration.....logistic support of Moon bases.....and
77.	Conceptual art	Deep space interplanetary probes. (FX sound)
78.	NASA Stock. Reprise of previous Saturn launch.	Noise will be an unwanted, but necessary by-product of these boosters.
79.	Continue Sc. 78.	We wish the noise could be controlled..... but it will not!
80.	NASA Stock. Reprise street scenes. General Cape scenes Saturn launch	We wish that those hearing this noise will feel priviledged to live in such an age.... privileged to live in such an area.... and to be a part of this fantasy to fact which will take place before the end of this decade.
81.	NASA Stock. Reprise of same street scenes as Scene 26.	We can reassure you that the National Aeronautics and Space Administration will take every precaution to assure you of as little interruption to your community life as possible.

	VISUAL	AUDIO
82.	NASA stock. Community scenes.	It is hoped that you will accept the occasional expected noise levels and accompanying inconvenience. (Theme music under Narrator)
83.	Conceptual art. General space concept. Dissolve to Astronaut.	Space travel has long been an imaginative dream of mankind. Now, for the first time, our science, our technology, and our economy can support the imagination of the past. Because.....
	Launch space craft.	we can explore space.....
		we must.....
84.	Conceptual art. Space theme.	Todays predictions will become tomorrow's accomplishments.
85.	Conceptual art of Moon landing	As Jules Verne, who wrote a fictional story of a trip to the Moon a century ago, said....
86.	NASA Stock. Saturn on Pad	"Anything One Man Can Imagine, Other Men Can Make Real." (FX sound)
87.	NASA stock. Saturn ignition	It's foolish to say....it can't be done.... for around the next corner is an open road... the future.....and..... (Continue FX sound)
88.	Launch.	The sound of the future.
89.	End Credits	

APPENDIX E

ACOUSTIC TEST LABORATORY

The Martin-Denver Acoustic Test Laboratory was developed and built in 1960 as part of the Titan silo launch program and has been in constant use ever since. The facility has been used for acoustic testing of ground and airborne components, sonic fatigue and vibration of structures, development of materials, and basic research. A shock tube is also available for ignition pulse testing. The Acoustic Test Laboratory is a completely self-contained facility with power, data acquisition, and data playback, etc. The facility is also very versatile, containing sufficient area and equipment for a variety of tests. The source power level of 180 decibels* will allow for full-scale testing of existing missile and/or space booster components and structure. Both sinusoidal and random testing are available.

Operation over this period of time has allowed facility modifications to provide for troublefree, efficient operation.

1. ACOUSTIC SOURCE

Random acoustic energy is produced by modulating the airflow through four counter-rotating rotors with randomly located ports. The rotors are driven by variable-speed dc motors. Mass flows of air as high as 20 lb/sec, 65 psig, are supplied during high-level tests. Sinusoidal acoustic energy is produced by a high-pressure (65 psig) siren. Both the random and sinusoidal sirens are connected to exponential horns.

Compressed air for the sirens is produced by an Allison TE-1 compressor unit driven by two modified Allison T-56 turboprop engines. This unit will provide up to 24 lb/sec of air at 65 psig. The air supply is automatically regulated. The compressed airstream is cooled to approximately 80°F by an aftercooling unit.

* Power-level reference, 10^{-3} watts.

2. CAPABILITIES

Random Noise - The reverberation chamber consists of an irregularly shaped 74-cubic-foot chamber coupled to the random noise source by an exponential horn with a cutoff frequency of 22 cps. Sound-pressure levels from 130 to 168 decibels* can be obtained in the chamber with a test specimen installed. Variations in overall sound-pressure levels throughout the chamber are less than 6 decibels. The ratio of peak-to-rms level throughout the chamber is 7 to 10 decibels.

Random plane-wave testing can be conducted on packages up to 2 cubic feet in size. This is accomplished by locating the specimen in the exponential horn that connects the random noise source with the reverberation chamber. For these tests, the reverberation chamber is converted into an absorptive termination for the exponential horn. Sound-pressure levels up to 172 decibels over a 1.5-square-foot test area can be obtained.

Random plane-wave testing can also be performed in the 55-square-foot test duct. Sound-pressure levels up to 150 decibels can be obtained. A 30-foot termination section, which is effective down to 30 cycles, prevents the generation of standing waves.

Complete missile or aircraft structural assemblies can also be acoustically tested in the system test area. Random noise levels up to 165 decibels can be achieved over a 9-square-foot section of the test specimen.

The test area provides the capability of testing missile or aircraft structures under normal or grazing incidences.

Static loads are simulated by hydraulically controlled loading heads.

Sinusoidal Testing - The plane-wave sinusoidal facility consists of an exponential horn, test duct, and termination section. The exponential horn provides for very high-intensity sinusoidal testing of specimens smaller than 2 cubic feet. Levels up to 175 decibels can be obtained in the test section of the horn. The frequency range of the sinusoidal source is from 20 to 2000 cps.

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*Sound-pressure level reference, 0.0002 dynes/cm^2.

Complete or partial missile and aircraft structures can be tested under sinusoidal excitation up to sound-pressure levels of 172 decibels over a 9-square-foot area and under either normal or grazing incidence. Higher sound-pressure levels (175 to 180 db) can be obtained over smaller surfaces.

3. DATA ACQUISITION

The Acoustic Test Laboratory has a completely self-contained data acquisition and playback system. This system is set up to afford maximum flexibility in measuring acoustic strain, vibration, and temperature data. The system is integrated to provide rapid tie-in to the various test areas and the assurance of accurate, calibrated data.

System capabilities are as follows:

1) Acoustics - One-third-octave spectral acoustic data can be analyzed during tests and recorded. Through appropriate switching circuits, the system can simultaneously analyze spectral data on two channels. In addition, acoustic data can be recorded on 36 wideband (0-10 kc) FM tape channels for detailed analysis after tests. Typical analyses that can be conducted are octave, one-third octave, fixed bandwidth, and constant percentage bandwidth. Complete system calibration, transducer-to-tape, can be performed on all acoustic data channels;

2) Vibration measurements - The system is capable of recording on wideband (0-10 kc) FM. The capability of post-test analysis of recorded accelerometer data is the same as the acoustic measurements with the addition of power spectral density analysis;

3) Strain - The system is capable of recording on wideband (0-10 kc) FM. Landline data flow channels are also provided to remotely monitor component input or output functions in the blockhouse. Sufficient space, electrical power, etc, are provided for instrumentation to monitor components.

4. CALIBRATION

A facility is provided at the Primary Standards Laboratory for the reciprocity calibration of primary microphones and the secondary freefield calibration of microphones. Freefield calibration can be conducted from 200 to 10,000 cps. Pressure calibration is performed from 20 to 200 cps. Calibration of accelerometers up to 10,000 cps is also available. All instrumentation is calibrated at regular intervals.

APPENDIX F

NEWS COVERAGE OF FLORIDA TESTS

HUGE SINUSOIDAL SIREN
. . . Can generate wall-shaking sounds

Sound Damages To Be Studied

CAPE KENNEDY — If you hear some unearthly roar the next time you are near the Cape's north gate, rest easy, a giant rocket is not about to go overhead.

It will be, rather, the low frequency rumble of a large sinusoidal siren, capable of producing sound that can rattle glass and shake structures.

The giant siren is being used in the area north of the Cape, and will eventually be used on Merritt Island, as part of an acoustical damage threshold study.

The study is being made by the Martin-Denver Company for the John F. Kennedy Space Center, NASA, to determine at what sound levels damage is done to ordinary buildings.

UNLIKE A previous series of tests where simulated structures test the sound blasts from actual Saturn I rockets, these experiments will use simulated rocket sound on actual houses.

The buildings being used are abandoned houses on NASA property. During the tests the siren is cranked up to a point where actual damage could be made to the buildings. Scientists want to find out precisely what this point is on typical local construction.

The siren is capable of emitting ear-splitting wails up to about 155 decibels. The generally-accepted safety level for humans to rocket noise is about 125 decibels.

So far there has been no damage to windows or structures, although sound levels, in a wide range of frequencies, has hit 145 decibels.

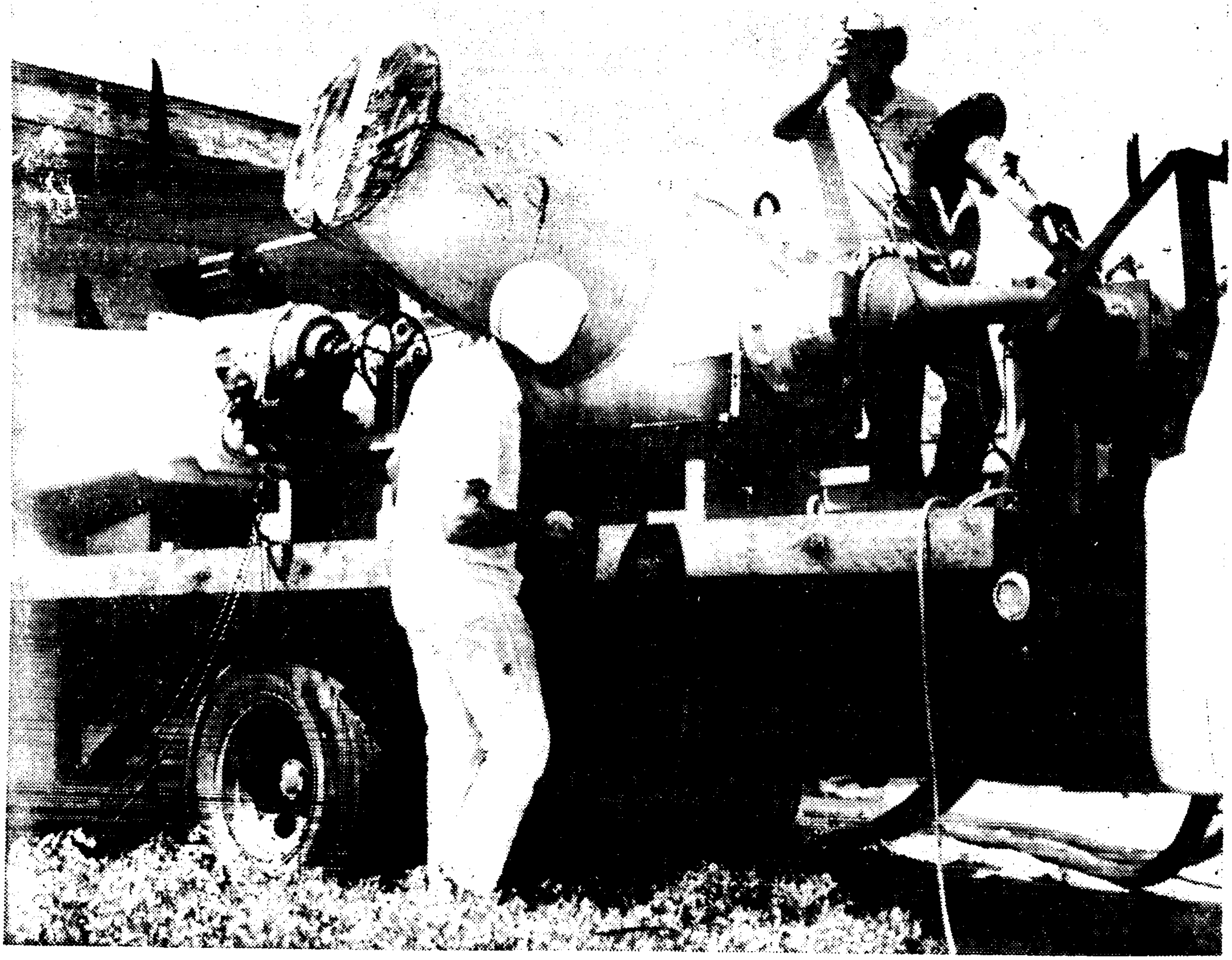
"WE RATTLED the heck out of some large picture windows," said Martin scientist John Baratono, "but so far we've had no breakage, and this is surprising."

The test series is divided into four basic phases. Phase No. 1 was a local community survey, which, rather than being a head count, was more of a study of buildings that could possibly be effected by rocket sounds. Building codes were studied and actual inspections of the structures were made.

Martin is now in the second phase of the study —the siren tests. These will continue most of the summer.

Then will come laboratory studies of the information gained, and finally, a detailed report of the findings to NASA.

Results of the tests will help scientists determine and define "buffer zones" to surround the launch areas of tomorrow's generation of giant rockets.



Immense Siren Checked

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Siren Tested at Cape Will Wake Up Neighborhood

CAPE KENNEDY — A huge siren that produces ear-splitting sound waves at close range is being tested by the National Aeronautics and Space Administration.

It's called a sinusoidal siren and it is capable of rattling glass and shaking structures at some distance.

The siren is being used as part of an accoustical damage threshold study to determine at what sound levels damage is done to ordinary buildings.

Rocket-like sounds burst in a deafening roar from the siren and are aimed at actual houses during tests.

Wails up to 155 decibels are emitted from the device. The generally accepted safety level for humans is 125 decibels.

Siren testing will continue throughout the summer. Results of the experiments will help scientists determine buffer zones required to protect buildings close to launch pads.

SUPER SINUSOIDAL SIREN SIMULATES SATURN SOUND

If you hear an unearthly roar the next time you drive out the Cape's north gate, rest easy, a giant rocket is not about to swoosh overhead.

It will be, rather, the low frequency rumble of a large sinusoidal siren, capable of producing sound that can rattle glass and shake structures.

This giant tooter is being used in the area north of the of the Cape, and will eventually be used on Merritt Island, as part of an Acoustical Damage Threshold Study.

The study is being made by the Martin-Denver Company for KSC to determine at what levels damage is done to ordinary buildings.

The buildings being used are abandoned houses on NASA property. During the tests the siren is cranked up to a point where actual damage may be inflicted on the buildings. Scientists want to find out precisely where this damage is and how it will affect typical local construction.

The siren is capable of emitting an ear-splitting growl of up to 155 decibels. The generally-accepted safety level at which humans can tolerate rocket noise is about 125 dbs.

So far there has been no damage to windows or structures, although sound levels, in a wide range of frequencies, have reached 145 dbs.

"We rattled the heck out of some large picture windows," said Martin scientist John Baratono, "but so far we've had no breakage, and this is surprising."

The test series is divided into four basic phases. Phase number one was a local community survey, a survey of buildings that could possibly be affected by rocket sounds. Building codes were studied and actual inspections of the structures were made.

Martin is now in the second phase of the study — the siren tests. These will continue most of the summer.

Then will come laboratory studies of the information gained, and finally, a detailed report of the findings.

Results of the tests will help scientists determine and define "buffer zones" to surround the launch areas of tomorrow's generation of giant rockets.

WITH SOUND-MUFFLING helmets on, acoustical scientists Ray Pitsker, and John Baratono of the Martin Company, Denver, set up their sinusoidal siren for a test run against the windows of an abandoned building north of the Cape.

Giant 'Baritone' Horn's Blasting Away at Cape

CAPE KENNEDY, Fla. — A giant "baritone horn," played by a team of Martin Company space scientists and engineers, has been put to work by the National Aeronautics and Space Administration (NASA) to determine what problems—if any—will be created by engine noise from giant space boosters of the future.

The horn is a special kind of siren, which plays selected tones so loudly that the effects duplicate the acoustic pressures generated by giant rocket engines.

The siren, built by Martin Company's Denver Division, is mounted on a flat-bed trailer. It's powered by four huge air compressors.

The noise level is about 145 decibels—extremely intense in the immediate vicinity of the siren. It can project acoustic pressure to an object a few feet away to simulate the sound effects that will occur several miles away from post-Saturn-era rocket engines.

The siren can break windows at close range. But it probably never will be heard—much less felt—in inhabited areas. The intense acoustic pressure diminishes rapidly with distance. Several hundred feet away it would sound much like a baritone horn in an orchestra.

The siren tests are being conducted on abandoned houses at the Merritt Island Launch Area (MILA) of the John F. Kennedy Space Center, NASA.

The houses will be subjected to sound pressure levels many times higher than inhabited areas will experience in space launchings now programmed. Damage will be caused deliberately, so that accurate data can be amassed. Relatively little detailed information on the effects of acoustic pressure on dwellings now exists.

The siren is of the sinusoidal type. This means that it produces sound at fixed levels, rather than undulating like fire engine siren or producing a roar containing many tones simultaneously, as do random sirens used in Martin-Denver's Acoustic Test Laboratory.

The program is scheduled to be completed by fall.

R. W. Peverley is project manager for Martin-Denver.

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